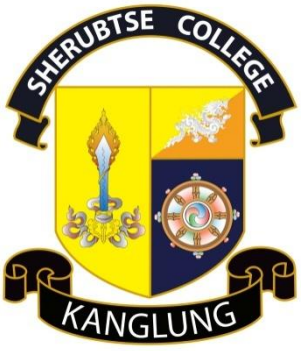

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ROYAL UNIVERSITY OF BHUTAN

SHERUBTSE COLLEGE

Definitive Programme Document for

Bachelor of Science in Statistics Programme

Royal University of Bhutan

July, 2021

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Programme Specification

1.1 Basic information on the programme

Name of the home base college:	Sherubtse College, Kanglung, Bhutan
Title of the award:	Bachelor of Science in Statistics
Duration and mode of study:	4 years, full time
Awarding Granting Body:	Royal University of Bhutan
Date of Initial Approval:	28-29 April, 2021, 17th USRC (validated)

1.2 Aims and Learning Outcomes of the Programme

1.2.1 Aims of the programme

The BSc in Statistics programme aims to provide students with necessary knowledge and skills to design a survey instrument, select a sample scientifically from the population under study, conduct survey to collect data, present data in various forms, analyze collected data and draw valid conclusions that could be used by decision makers. The programme includes a base of theoretical work complemented by practical analysis of real-world data and a capstone project to give them training in applying and sharpening the skills they have acquired during the course of the programme.

It also trains the students to use various statistical packages to analyse data, extract necessary parameters, set and test hypotheses and draw meaningful inferences thereby preparing technically proficient statisticians.

In order to provide wholesome education and personal development to the students some general education modules are included in the programme. Through these modules, the students will gain oral and written communication skills, awareness about local and global cultural values, leadership and interpersonal skills.

The students of the programme acquire skills to study real-world issues which are novel in nature and find a workable solution by developing new models that fit the identified problems which is a distinctive skill not provided by the other programmes offered in the college.

1.2.2 Learning outcomes of the Programme

Upon completion of the programme, graduates will be able to:

1. Select a representative sample from the population under study and administer survey to collect relevant data.
2. Organize and present data in suitable form (diagrams, graphs, measures etc.).
3. Use statistical software(s) such as R, Python and Spreadsheet for data analysis.
4. Apply statistical methods and modeling techniques to real-world problems in both observational and designed studies.
5. Coordinate and work with multidisciplinary teams.
6. Display a capacity for logical thinking, structured reasoning and synthesis skills

7. Identify critical research issues and propose methodologies in statistics.
8. Employ their knowledge and expertise for the development of a research enquiry and to select the tools necessary for executing the research.
9. Discuss, debate, and communicate ideas in a clear and logical way.
10. Demonstrate independent and lifelong learning skills through capstone project.
11. Apply economic reasoning to the analysis of contemporary economic problems.
12. Demonstrate how political, economic, and social structures affect historical change.
13. Demonstrate ability to work as a team, listen and respond to others, and use negotiation and conflict-resolution skills.

1.3 Career related opportunities

Statistics is an indispensable tool in this modern age where everything revolves around planning and decision making. The governments of most of the countries around the world are constantly researching to improve their socio-economic development strategies. Statistical data and techniques of statistical analysis are immensely useful in solving economic problems such as wages, price, time series analysis, and demand analysis. It is an irreplaceable tool of production control. Business executives are relying more and more on statistical techniques for studying the preference of the customers.

Careers that incorporate statistics can be found in a wide variety of disciplines such as financial institutions, insurance companies, investment management, education, research institutions, agriculture, business, industry, computer science, health sciences, government and private sectors. After getting adequate experience, graduate of this programme can also compete in international job market in data analysis, quality control and production management.

1.4 Programme Structure

Year 1	Semester I	ACS101 Academic Skills	CAL111 Calculus	DST101 Descriptive Statistics	ALG107 Set Theory and Theory of Equations	PLT102 Programming in Python
	Semester II	DST102 Probability Theory	CAL206 Differential Equations I	ADS101 Data Structures and Algorithms	ALG108 Matrix Analysis and Vector Spaces	DZG101 རྩོང་ཁ་བད་དོན་སྒྲིལ་བ།
Year 2	Semester I	DST203 Probability Distributions I	PLT203 R Programming for Data Analysis	AMT209 Mathematical Logic	CAE201 Database Systems	ECO101 Fundamentals of Economics
	Semester II	DST204 Probability Distributions II	AMT210 Numerical Methods	ANY207 Real Analysis	IST201 Sampling Theory	GSE101 Analytical Skills
Year 3	Semester I	IST303 Statistical Inference	IST302 Regression Analysis	IST304 Nonparametric and Sequential Methods	RSM301 Research Methods	EDP101 Entrepreneurship
	Semester II	IST305 Statistical Quality Control	AMT311 Introduction to Operations Research	AMT312 Stochastic Processes	IST306 Multivariate Analysis	PMT301 Project Design and Management
Year 4	Semester I	IST407 Mathematical Demography and Actuarial Statistics	IST408 Design of Experiments	MQM405 Econometrics	IST409 Forecasting Techniques and Statistical Modelling	DSC201 Machine Learning
	Semester II	IST410 Survival Analysis and Biostatistics	RSM412 Capstone Project			

The structure of the programme is progressive in nature where in the first year foundation modules will be taught and the second year modules are built on these foundation modules. Third year modules are of advanced level for which the knowledge of first and second year modules are necessary. In the fourth year, the focus is on specialized statistics knowledge so that they are at par with students of such programme in other parts of the world. During the fourth year, the students are expected to work independently for assignments and presentations. For most of the modules in the fourth year, students are expected to search for research articles, read them and present the same in the class which will be assessed as a part of continuous assessment.

The programme is based on a semester system with five modules in each semester where at least one will be a general education module. The year 4, semester II will have a capstone project worth 36 credits. Each module is of 12 credits and in each semester a student is expected to earn 60 credits. To earn BSc in Statistics degree a student has to secure 480 credits.

Modules categorized by sub-discipline of the programme

DST – Descriptive Statistics
IST – Inferential Statistics
MQM – Mathematical Quantitative Methods
RSM – Research Methods
CAE – Computer Architecture and Engineering
PLT- Programming Language Techniques
ALG- Algebra
ANY- Analysis
AMT- Applied Mathematics
ADS-Applied Data Structures
DZG-Dzongkha
ECO-Economics
GSE- Global Skills Enhancement
CAL-Calculus
DSC-Data Science
ACS-Academic Skills
EDP-Entrepreneurship
PMT-Project Design and Management

Modules borrowed from other programmes

No.	Module	Borrowed From
1	ACS101 Academic Skills	University-wide module
2	DZG101 Dzongkha Communication	University-wide module
3	CAL206 Differential Equations I	BSc in Mathematics
4	DSC201 Machine Learning	BSc in Data Science
5	ECO101 Fundamentals of Economics	BA in Population and Development Studies

6	EDP101 Entrepreneurship	University-wide module
7	GSE101 Analytical Skills	University-wide module
8	PMT301 Project Design and Management	BA in Population and Development Studies
9	RSM301 Research Methods	BSc in Environmental Science

1.5 Learning and Teaching Approach

The programme aims to promote student-centered learning process. Lectures will be delivered through conventional mode blended with demonstrations and presentations. As students progress to the higher semesters, learning process will be more student-centric, where students are expected to work independently. For most of the modules there will be either a tutorial class or a lab session, scheduled every week. During the tutorial class, the students will be divided into smaller groups and they will be asked to work on pre-assigned theorems and problem sets. The tutors will supervise and assist the students by giving them hands on problem-solving techniques. They will be encouraged to come up with problems they face in that module which will be subsequently addressed by the concerned tutor. During the lab session, supervised hands-on practice related to programming, use of open-source data analysis packages and guidance to work on projects will be provided. By this process, students will be able apply the concepts taught in the lecture sessions.

Effective use of ICT will be encouraged and the tutors will make use of the VLE platform for sharing the available free e-resources. To synergize supervised and independent learning, students will be continuously monitored and will be expected to show progress learning.

1.6 The Assessment Approach

The assessment will be consistent with the assessment rules and regulation as per the Wheel of Academic Law (WAL) of RUB ensuring the principles of Validity, Reliability, Transparency and Fairness in the programme. The programme has a variety of assessment approaches depending upon modules' specific needs and learning outcomes. Different assessment approaches will ensure the achievement of learning outcomes of each module and test the skills and abilities that the students have gained from studying a particular module. Generally, assessment will include continuous assessment components (Assignments, Presentations, Group work, Class test, Mid-semester exam, Project, Quizzes through VLE and laboratory exams wherever it is applicable) and Semester-end examinations. The weighting for the continuous assessment and Semester-end examinations differ according to the nature of the module (refer module descriptors).

1.7 Regulations

1.7.1 Entry requirements

The admission for the programme will be routed through the University's common online admission system. The candidates will be selected through merit ranking based on the eligibility criteria given below. The weighting assigned to a subject is based on the relevance of the subject to the programme. The selection criteria are subject to revision as per the admission policy guideline of the RUB and Sherubtse College.

Entrance requirement for the programme

Eligibility Criteria	Ability Rating Points
Class XII pass science students with a minimum of 55% in Mathematics.	Mathematics - 5 4 other subjects - 1

Applicants who have not studied Dzongkha in class XII should have passed it in class X. A proficiency test in Dzongkha will determine the eligibility of Bhutanese applicants who have not studied Dzongkha in either class X or XII. The test shall be administered by the Registry, RUB. Marks secured in the proficiency test/class X will be scaled down to 40% and applied for merit ranking.

1.7.2 Assessment and progression requirements

To pass a module a student must obtain a minimum of 50% overall including both the continuous assessment (CA) and semester-end examination (SE). However, a student must obtain a minimum of 40% each in CA and SE.

1.7.3 Re-assessment

A student is eligible for re-assessment if the number of failed modules is less than 30% of the total number of modules prescribed for the semester. Upon passing the failed module(s) in re-assessment, a student will not be awarded more than 50%, this being the minimum pass mark.

1.7.4 Repeat Module(s)

A student may repeat a failed module any number of times within the normal registration period for completing an award where he or she:

- has failed in the re-assessment of a module(s). In such an event, the student shall meet all assessment requirements of those modules, both CA and SE. For students under this category, attendance in lectures is not mandatory.
- has failed more than 30% of the total number of modules prescribed for that semester. In such an event the student shall meet all teaching, learning and assessment requirements of the failed modules. For students under this category, attendance in lectures is mandatory.
- For any particular semester, a student cannot register for more than 2 repeat modules in addition to the modules prescribed for the semester

1.7.5 Role of Programme Board of Examiners

The Board of Examiners shall, in the light of the University's general assessment regulations and the programme specific regulations, determine, for each module, the mark to be assigned to each student's performance. The Programme Board of Examiners shall determine whether each student shall:

- be eligible for an award
- be allowed to continue on the programme, possibly with provision for re-assessment in certain modules and/or for the repeat of certain modules, or
- be required to withdraw from the programme

A detailed information on progression criteria is available in “D1 Re-assessment and Repeat of a Module” of “The Wheel of Academic Law” (www.rub.edu.bt).

1.8 Planned Student Numbers

The proposed student intake for the next five years for the programme is reflected in the following table.

Year	2021	2022	2023	2024	2025
Year 1	30	30	30	30	30
Year 2		30	30	30	30
Year 3			30	30	30
Year 4				30	30
Total	30	60	90	120	120

1.9 Programme Management, Quality Assurance and Enhancement

To ensure quality and proper monitoring both in terms of delivery and assessments, a closely coordinated system of programme management mechanisms are in place that is in line with the guidelines spelt in “The Wheel of Academic Law” (www.rub.edu.bt) and the “Academic Affairs Guidelines” (www.sherubtse.edu.bt). This is enabled through specific responsibilities delegated to dedicated staff and institution of several committees, and through timely student feedback, as outlined below.

The following sections provide an overview of the mandatory university-wide quality assurance and enhancement procedures:

Dean of Academic Affairs (DAA)

DAA maintains and implements academic regulations/guidelines, supports and implements innovative approaches to teaching-learning and quality across all programmes in the College. DAA is responsible for maintaining the health of all programmes at the College.

Head of the Department (HoD)

HoD provides organizational and academic leadership for programmes offered by the department, and is accountable to the DAA in the day-to-day operations. HoD is responsible for maintaining the health of programmes within the department.

Programme Leader (PL)

PL provides organizational and academic leadership for the programme and is directly accountable to the HoD. PL is responsible for maintaining the health of the programme and reporting issues related to the programme to appropriate committees. PL is also responsible for drafting the Annual Programme Monitoring Report and it’s reporting to the Programme Committee and College Academic Committee and final submission to the Programmes and Quality Committee.

Module Tutor (MT)

MT is directly accountable to PL and is responsible for teaching and assessment of a particular module as per the semester plan agreed upon with the PL. Importantly, MT evaluates the relevancy and currency of the module descriptor and recommends need for updates to the PL. When there are multiple tutors teaching the same module, a Module Coordinator (MC) is appointed, who is responsible for ensuring the health of the module as per the definitive

programme document. At the conclusion of the semester, the MT (or the MC) prepares module reports for the modules taught in the semester. Module reports provide insights on issues related to the delivery of modules and plan of actions for the subsequent year, which are reported in the Annual Programme Monitoring Report.

College Academic Committee (CAC)
CAC is the highest decision-making body for all matters related to academic affairs in the College. In particular, CAC serves as the guarantor of academic standards and quality in respect of the design, delivery, development and promotion of best practice in curricula, programmes, general educational matters and research within the College. It is responsible for implementation of the University academic quality assurance policies and procedures covering the development and the monitoring of taught programmes, learning and teaching and the academic support of students within the College. CAC is chaired by the DAA, with members constituting of President, Dean of Student Affairs, Dean of Research & Industrial Linkages, elected staff representatives (HoDs & selected PLs), elected student representatives (two student leaders), representative of other groups of staff (Librarian & ICT Officer), an external member and one senor academic as a secretary.

Programme Committee (PC)
At the programme level, PC is responsible for the effective conduct, organization and development of the programme, including appointment of module tutors, allocation of teaching-learning resources required for the semester. PC is chaired by the PL, with all MTs/Module Coordinators of the programme and at least three students of the programme representing different cohorts, constituting the membership.

Student Consultative Meetings (SCM)
The purpose of the SCM is to involve students in the operation of programmes and in improving the effectiveness of their own education. The SCM is convened at the Departmental level once in the mid-semester. The meeting provides a forum for the students to provide feedback on all elements of the programme such as the delivery of the modules; the subject matter of the modules; the effectiveness of the teaching, learning and assessment approaches; the adequacy of teaching learning resources; progression and achievement; guidance and support as well as examples of good practice. The SCM is chaired by DAA, with HoD, PLs and at least two student representatives from each year of the programme constituting the membership.

Student Module Evaluation (SME)
SME is another quality assurance and enhancement mechanism in which students are engaged in the assurance and enhancement of their educational experience. Through this mechanism, the College seeks feedback from all the students enrolled for the module in terms of module delivery, resources available, quality of learning and teaching, relevance of assessment methods, and the professionalism of module tutors. SME is done at the end for semester through use of RUB-wide standard module evaluation form, integrated to the VLE. The line managers (Programme Leaders, Head of Departments and Dean of Academic Affairs) at the College review the feedback for every module and actions are taken when the new semester starts.

Annual Programme Monitoring Report (APMR) and Module Report (MR)
APM is a key component of the University's quality assurance and enhancement processes which provides assurance of the continued quality, standards and relevance of programmes in operation. APMR ensures that programmes leading to an award of the University meet their aims and learning outcomes effectively, while at the same time, it strives to enhance the quality of learning and teaching at the University. It is a continuous process of appraising the performance

of programmes throughout the year culminating in a consolidated Annual Programme Monitoring Report at the end of the academic year. Programme Leader is responsible for compiling the APMR.

The MR provides a critical appraisal of the delivery of a module by reviewing its current strengths and weaknesses, and provides evidence upon which to plan the improvement of the module. It feeds the APMR by providing informed, evidence-based action points for the programme of which the module forms a part. Module tutor (or the module coordinator) is responsible for producing the module report.

Programme Board of Examiners (PBoE)

As outlined in "The Wheel of Academic Law", the PBoE ensures that module assessments are in compliance with the validated/reviewed module descriptors and the progression of students to the next level is assessed in compliance with RUB regulations. PBoE is chaired by a senior member of the staff cognisant of the programme but not closely involved in it, with HoD, PLs, staff with assigned responsibility for assessments, and an external examiner appointed by the Academic Board constituting the membership.

Moderation of Assessments

Moderation is a quality assurance process to ensure assessment is accurate, consistent and fair. It also assures that the results are an accurate reflection of performance and can be relied upon by students and staff within the university, as well as by external stakeholders. As required by the RUB regulation: "D8 Moderation of Assessments" of "The Wheel of Academic Law" (www.rub.edu.bt), at Sherubtse College all 'assessment tasks' and 'assessed student works' constituting 20% or more of the total assessment weighting of a module are moderated through internal and external moderation process. Internal moderation is done by a moderation committee, consisting of tutors from same discipline, who may or may not teach the module. External moderation is the review of examination questions and a representative sample of answer scripts, and assessed components of continuous assessment tasks for a module by the external examiner(s) for a programme.

Role of External Examiners

External examiners are independent advisers for a programme in operation. They contribute to the quality assurance and enhancement of a programme by providing an external view on assessments, student achievements, academic standards and a range of academic matters related to the delivery of a programme. The roles and responsibilities of external examiners are outlined in regulation D3 "External Examiners" in The Wheel of Academic Law.

In addition to the university-wide mandatory procedures, Sherubtse has instituted the following internal quality assurance and enhancement initiatives:

Department Academic Committee (DAC)

Given multiple programmes offered by each department at Sherubtse College, the DAC of Mathematics and Computer Science is mandated with the responsibility of promoting academic quality and standards of the department, besides implementing resolutions of the CAC at the departmental level. The committee is chaired by the HoD, with PLs and all MTs constituting the membership.

Semester Guide (SG)

At Sherubtse College one staff is appointed as SG from among the module tutors for each cohort of students for every programme. SG is responsible for giving guidance on both academic and non-academic matters, which includes counseling/parenting, advising on class attendance records, and reporting specific academic needs of students to MT and PL.

1.10 Academic Staff

The current staff profile of the Department of Mathematics and Computer Science which hosts the programme at Sherubtse College is reflected in the following table:

Faculty Profile of the Department of Mathematics and Computer Science					
Area	**Name**	**Designation**	**Qualification**	**Exp.**	**Status**
Mathematics	Mr. R. Balamurugan	Assistant Professor	MSc, MPhil	32	Fixed-term
	Mr. Thinley Namgyel	Lecturer	MSc	13	Regular
	Mr. Pema Tshering	Associate Lecturer	MSc	10	Regular
	Mr. Pema Wangdi	Associate Lecturer	MSc	10	Regular
	Mr. Dechen Lhendup	Assistant Lecturer	MSc	5	Regular
	Mr. Ugyen Samdrup Tshering	Assistant Lecturer	Pursuing master	1	Regular
Computer Science	Mr. P. Paulraj	Assistant Professor	MCom, MPhil, ANC (NIIT)	19	Fixed term
	Mr. Sangay Thinley	Lecturer	MCS	15	Regular
	Mr. J. Gurubalan	Lecturer	MSc, BEd	8	Fixed-term
	Mr. Karma Dorji	Associate Lecturer	MCS	10	Regular
	Mr. Phub Namgay	Associate Lecturer	MCA	6	Pursuing PhD
Statistics	Mr. Dawa Wangchuk Gyelpo	Assistant Lecturer	Pursuing master	1	Regular
	Ms. Chimi Lhazom	Assistant Lecturer	BSc	1	Regular
	Ms. Samten Choden	Associate Lecturer	MSc	10	Regular

The existing four faculty members will be sufficient to teach the first year of the programme. Before the CPL faculty leaves, the College is planning to recruit additional faculty member to teach the programme. As the cohort progresses to the higher level, the College has to recruit additional 6 faculty members (2 by autumn 2022, 2 by autumn 2023 and 2 by autumn 2024) so that the programme is delivered as expected. The details of recruitment plan and specialization required are given in the following table:

Plan for recruitment

Cohort	2021-22	2022-23	2023-24	2024-25
Student Number	**30**	**60**	**90**	**120**
S-F ratio	2	4	6	8
Regular	2	2	4	5
Fixed	1	0	1	1
Excess	1	0	0	0
Short	0	2	1	2
Recruitment Plan		2(1-R 1-FT) June 2022	1R June 2023	2(1-R, 1-FT) June 2024
Qualification		MSc/BSc	MSc	1-PhD & 1-MSc
Specialization		Mathematics/ Statistics	Statistics	Statistical Inference/ Biostatistics

*S-F=Student-Faculty, R- Regular, FT- Fixed-term

Identified faculty members will be sent for Professional Development (PD) on R programming, Python for data analysis, spreadsheet for data analysis and advanced topics in statistics based on the need of the programme. The cost of these PD programmes will be met from the college HRD fund.

Professional Development Programmes

S.No	Activity	No. of Participants	Timeline	*Estimated Cost (Nu. In million)	Source of Funding
1	Research Method	2	Spring, 2023	0.2	College
2	R/Python	2	Spring, 2023	0.1	College
2	Statistical Quality Control	1	Autumn, 2023	0.1	College
3	Stochastic Processes	1	Autumn, 2023	0.1	College
4	Mathematical Demography and Actuarial Statistics	1	Spring, 2024	0.1	College
5	Design of Experiments	1	Spring, 2024	0.1	College
6	Forecasting Techniques	1	Spring, 2024	0.1	College

	and Statistical Modelling				
7	Machine Learning	2	Autumn, 2024	0.2	College
8	Survey Analysis and Biostatistics	1	Autumn, 2024	0.1	College

* The cost of each PD programme has been estimated based on a 6 months long online programme that includes a capstone project. At the end of the programme participants receive a post graduate certificate.

1.11 Resource needs

Accommodation

With the phasing out of programmes and reduction in student intake for various programmes offered at Sherubtse College, there would not be a problem in terms of availability of classrooms, accommodation and other academic facilities.

Equipment

The programme does not require any specialised equipment for smooth delivery. The necessary equipment such as overhead projectors and smartboard are already put in place.

Library Support

The college will invest to procure library resources required for the programme as per the following table

Year & semester	Cost (Nu.)	Timeline
Year 1 semester I	39,027.20	Spring 2021
Year 1 Semester II	179,065.32	Autumn 2021
Year 2 Semester I	110,441.00	Spring 2022
Year 2 Semester II	216,862.30	Autumn 2022
Year 3 Semester I	426,419.60	Spring 2023
Year 3 Semester II	351,088.00	Autumn 2023
Year 4 Semester I	321,984.64	Spring 2024
Year 4 Semester II	98,093.00	Autumn 2024
Total	**1,742,981.06**	

In addition, the college library has also subscribed to ProQuest eBook Central which gives access to various titles in Statistics. With these resources in place, the college is adequately equipped to run the programme successfully.

Computing Support

At present, the college has three computer labs with thirty computers each. The college has 84 Mbps bandwidth connectivity and all the computers in the labs are connected to the Internet. Two

labs have computers with Maple software. Further, open-source software such as R and Python are available for lab sessions. This will be sufficient for lab classes for the intake of thirty students.

Other Support Facilities

The college has the following support facilities for the smooth functioning of the programme:

- Reading Space: There are spacious reading places in the library, student service centre and around the academic block of the College for students' use after class hours.
- Wi-Fi connections are available around the academic blocks, student service centre, library and the administrative building. Further, there is a dedicated lab with Wi-Fi facilities available from 8.30 am to 10 pm for the students' use.
- Student service centre also has a counselling centre with the three trained counsellors who are available as and when students require. Further, a toll-free number 6006 can be contacted any time for availing counseling related services.
- Student service centre also has Happiness and Wellbeing Centre that frequently conducts Mindfulness and Yoga sessions which can be attended by interested students. It also has a mini library with books related to mindfulness and personality development.
- Student Service Centre also hosts a reprographic centre where students can avail printing and photo copying services with nominal charges.

Module Descriptors

Year 1 Semester I

ACS101: Academic Skills

Module Code and Title: ACS101 Academic Skills
Programme: University-wide Module
Credit Value: 12
Module Tutor: Faculty member from English
Module Coordinator: Mrs**.** Wangmo

General Objective
This module aims to develop the knowledge and understanding of a range of academic skills required for study at university level. The module will focus on the development of academic writing, oral presentation, as well as listening skills to enable students to communicate effectively in both spoken and written forms. The module will enhance their learning throughout their studies at university and beyond, through close reading, discussions and critiquing of academic texts. Further, it will also enhance students' capacity to critically reflect on their own learning.

Learning Outcomes
On completion of the module, students will be able to:

1. use effective note taking skills to extract relevant information from a range of academic texts.
2. lead and participate productively in group situations.
3. apply features of academic writing in academic discourses.
4. apply learned strategies to avoid the consequences of academic dishonesty.
5. employ a range of strategies and techniques to read academic texts.
6. demonstrate information retrieval and analysis skills by identifying, assessing and using appropriate sources i.e. author, publisher or website.
7. identify the content, viewpoint and relevance of articles and reports on a wide range of topics.
8. write academic papers using a process approach: planning, drafting, eliciting feedback and revising, following consistent academic standards.
9. construct a coherent and substantiated argument that integrates appropriate source material, and uses appropriate research and APA referencing conventions in clear and correct language in the form of an essay.
10. produce academic essays using process approach: planning, drafting, eliciting feedback and revising using appropriate terminology and a consistent academic style.
11. plan, organise and deliver a clear, well-structured academic oral presentation.

Teaching and Learning Approach
Tutors will employ an interactive, student-centred approach, integrating language and critical thinking skills using the following strategies: demonstrations/modelling, practical exercises and activities, group work (discussions, problem-solving activities, collaborative and individual tasks, peer feedback and debates), academic essay writing (process learning with diagnosis, feedback and remediation), oral presentation, portfolio, independent study and VLE discussions over the 120 credit hours.

Approach	Hours per week	Total credit hours
Demonstrations/Modelling	1	15
Practical exercises and group work	2	30
Academic essay writing	1	15
Oral presentation	0.5	7.5
Portfolio	1.5	22.5
Independent study and VLE discussions	2	30
Total		**120**

Assessment Approach

Since the module is entirely assessed through continuous assessment, a student must complete all five components of the assessment outlined below and get an aggregate mark of 50% in order to pass. Assessment will be carried out on a continuous basis through the following tasks:

A. Academic Essay: Portion of the Final Mark (30%)

Students have to write one 800 to 1000-word academic essay following the rules of academic standards, essay writing, APA referencing and mechanics of language in order to practice and develop academic writing skills at the university level. The academic essay will be written in three drafts; the first draft to be peer reviewed, the second and final essay to be assessed based on the following criteria:

Second Draft (10%)	Final Draft (20%)
Content (4%)	Content (10%) (*Introduction-3%, Body-5%, Conclusion-2%)*
Language (2%)	Language (4%)
References (2%)	References (4%)
Format (2%)	Format (2%)

B. Presentation: Portion of the Final Mark (15%)

Each student has to make one 5-7 minute presentation. This will help them acquire the skills necessary for carrying out effective oral presentations during the course of their university study. The students can choose one presentation topic related to their Academic Skills module, programme or an evidence-based subject that interests them for this task. The presentations will be assessed based on the following criteria:

Greetings (3%)

- *Introduction*
- *Topic*
- *Overview*

Content (4%)

- *Clarity*
- *Discussion*
- *Evidence*
- *Coherence*

Delivery (5%)

- *Pronunciation*
- *Grammar*
- *Tone and pitch*
- *Body language*

Visual Aids (2%)

- *Effectiveness*
- *Relevance*

Time Management (1%)

- *Coverage*
- *Conclusion*

C. Portfolio: Portion of the Final Mark (25%)

Each student has to maintain a portfolio containing series of exercises from both within and outside the class. This is to ensure the development of independent study, skills and ability to work with other students. The portfolio will be assessed based on the following:

- Organisation (5%)
- Class Work (8%)
- Class Notes (5%)
- Homework (7%).

D. Class Test: Portion of the Final Mark (20%)

Students have to write one class test towards the end of week seven. The test will mainly focus on referencing skills.

E. VLE Discussion: Portion of the Final Mark (10%)

Students will contribute to VLE discussions on selected topics assigned by tutors.

- Frequency (5%)
- Relevance (5%)

An overview of the assessment approaches and weighting:

Areas of assessment	Quantity	Weighting
A. Academic essay	1	30%
B. Oral presentation	1	15%
C. Portfolio	1	25%
D. Class test	1	20%
E. VLE discussion	2-5	10%

Pre-requisite: None

Subject Matter

Unit I: Academic Standards

1.1. Definition
1.2. Purpose of Academic Activities
1.3. Ethics and Integrity

Unit II: Note-taking

2.1. Basics of note-taking

2.1.1. Storing information during lecture sessions

2.2. Types of notes and strategies
- 2.2.1. Pattern Notes or Mind Maps
- 2.2.2. The Cornell Method
- 2.2.3. The Outlining Method
- 2.2.4. Symbol and Abbreviation Method

2.3. Listening and note-taking
- 2.3.1. Practicing Listening with the partners
- 2.3.2. Listening to BBC service podcasts
- 2.3.3. Listening to IELTS test samples

Unit III: Academic Writing

3.1 Academic Writing
- 3.1.1 Definition
- 3.1.2 Importance of academic writing
- 3.1.3 Identifying various academic texts
- 3.1.4 Applying academic features in writing for academic purposes

3.2 Features of academic writing
- 3.2.1 Formality
- 3.2.2 Structure
- 3.2.3 Logic
- 3.2.4 Evidence and sources
- 3.2.5 Objectivity
- 3.2.6 Precision

3.3 Types of academic writing
- 3.3.1 Essays
- 3.3.2 Reports
- 3.3.3 Exam responses
- 3.3.4 Academic assignments
- 3.3.5 Proposals (Research and project)

3.4 Academic argument
- 3.4.1 Definition
- 3.4.2 Distinction between academic argument and everyday argument
- 3.4.3 Facts, opinions and beliefs

Unit IV: Referencing Techniques and APA format

4.1 Types of referencing styles
- 4.1.1 Documentary note styles
- 4.1.2 Parenthetical styles or author-date styles
- 4.1.3 Numbered styles
- 4.1.4 Why and when to cite

4.2 Introduction to using source materials
- 4.2.1 Defining sources
- 4.2.2 Critical evaluation of resources

4.3 Using source materials for in-text citation
- 4.3.1 Direct and Indirect/Reported voice

4.4 Making end-text/reference lists
- 4.4.1 Writing references for books, newspapers, websites and scholarly journals

4.5 Referencing and academic integrity
- 4.5.1 Understanding plagiarism and its consequences
- 4.5.2 Maintenance of academic standards

4.5.3 Honesty and rigor in academic writing and publishing
4.5.4 Following academic ethics

Unit V: Academic Essay Writing

5.1 Writing Process
5.1.1 Pre-writing, Drafting, Revising, Editing and Publishing
5.2 Understanding Written Assignments
5.2.1 Instruction words
5.2.2 Content words
5.2.3 BUG method
5.3 Academic Essay
5.3.1 Purpose and features of academic essays
5.4 Essay Format/Structure
5.4.1 Introduction- Opening statement, background information and thesis statement
5.4.2 Body paragraphs
5.4.3 Conclusion

Unit VI: Academic Reading

6.1. Text features and organization
6.1.1. Textual Features
6.1.2. Graphic Aids
6.1.3. Informational Aids
6.1.4. Organizational Aids
6.2. Reading Techniques
6.2.1. Skimming
6.2.2. Scanning
6.2.3. SQ3R
6.3. Introduction to Using Source Materials
6.3.1. Locating, evaluating and selecting information
6.3.2. Internet Source- Web endings
6.4. Summarizing and Paraphrasing academic texts
6.5. Critical reading (author viewpoints/biases, reading for detail)

Unit VII: Oral Presentations

7.1 Basics of oral presentation
7.1.1 Definition and Examples
7.1.2 Tips to Overcome Anxiety in Oral Presentation (Controlling Nervousness, Controlling Physical Nervousness, Capitalizing on the Law of Attraction)
7.1.3 Organising the Content (Introduction, Body, Conclusion)
7.2 Strategies for delivering an effective presentation
7.2.1 Signposting (Introducing topic of presentation, outlining the structure of presentation, indicating the start of new section, concluding)
7.2.2 Using Visual Aids
7.2.3 Sense of Humour
7.2.4 Body Language
7.2.5 Tone and Pitch

Reading List
Essential Reading

American Psychological Association. (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.
Department of Academic Affairs. (2018). *Students' materials for academic skills*. Thimphu: Royal University of Bhutan.
Department of Academic Affairs. (2018). *Tutors' materials for academic skills*. Thimphu: Royal University of Bhutan.

Additional Reading

Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). Abingdon, Oxford: Routledge.
Butler, L. (2007). *Fundamentals of academic writing*. New York, NY: Pearson Longman.
Gillet, A. (2013, January 15). *UEFAP (Using English for academic purposes): A guide for students in higher education.* Retrieved from http://www.uefap.com
Gillet, A., Hammond, A., & Martala, M. (2009). *Inside track successful academic writing.* England: Pearson Education.
Hogue, A. (2007). *First steps in academic writing*. New York: Pearson Education ESL.
Oshima, A., & Hogue, A. (2005). *Writing academic English* (4th ed.). White Plains, NY: Pearson Education.
Oshima, A., & Hogue, A. (2006). *Introduction to academic writing* (3rd ed.). New York: Pearson Longman.
Ramsey-Fowler, H., & Aaron, J. E. (2010). *The little brown handbook* (11th ed.). New York, NY: Pearson Longman.

Date: 29 June 2018

CAL111: Calculus

Module Code & Title: CAL111 Calculus
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Pema Tshering

General Objective

The module introduces fundamental concepts of mathematical typesetting using LaTex. The module will also help students to explore concepts, properties and aspects of differential and integral calculus of single and multivariable functions.

Learning Outcomes

On completion of the module, students will be able to

1. Use LaTeX for typesetting mathematical documents and journal articles formats.
2. Label equations while typing mathematical articles.
3. Use beamer class as an alternative for presentations with numerous mathematical symbols and equations.
4. Differentiate functions using different rules of differentiation.
5. Find limits of multivariable functions.
6. Explain the concepts of partial differentiation.
7. Explain the rules and methods of integration
8. Explain the concepts of double and triple integration.
9. Use double and triple integrations to find expected values of a probability distribution function.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	4	**75**
	Tutorial	1	
Independent study	Written assignment	1	**45**
	Self-study	2	
Total			**120**

Assessment Approach

A**: Assignments: 10%)**

An individual assignment will be given during the first half of the semester. The assignment will comprise of problem solving and questions will be given from units II, III and IV. The assignment will be evaluated broadly on the following criteria:

- Evaluation of limit, checking continuity and finding derivative 2 marks
- Finding extreme values 2 marks
- Checking continuity and finding partial derivatives 3 marks
- Finding extreme values of a multivariate function 3 marks

B**: Class Test: (10%)**

Class test will be conducted to give students the preview of semester-end examinations and to maintain check and balance in the assessment process. A class test of one hour duration will be conducted before the semester-end examinations. The questions will be included from the subject matters covered after mid-semester exam.

C**: Mid-Semester Examination: (20%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the module being covered for the duration of one and half hours. The total weighting of the examination paper should be 40 and the marks obtained in the examination will be converted into 20%

Semester-end Examination: (60%)

Semester end Examination will be conducted for the duration of three hours and questions will be from all the units of the subject matter of the module. The total weighting of the examination will be 60. Test blue print of the question paper and an answer key for grading will also be prepared along with the question paper

Overview of Assessment Approaches

Areas of assignments	Quantity	Weighting
A. Assignments	1	10%
B. Class Test	1	10%
C. Mid-Semester Examination	1	20%
D. Semester-end Examination	1	60%

Pre-requisite: None

Subject Matter

Unit I: Introduction to LaTex

1.1 Introduction to mathematical typesetting with LaTeX

1.2 LaTeX processing modes

1.3 Typesetting packages

1.4 Mathematics fonts: alphabetic and symbolic, hyphens, dashes, minus signs, dots, delimiters, math accents
1.5 Commands with arguments and some mathematical environments
1.6 Typesetting mathematical formulae
1.7 Grouping in Math mode
1.8 Building Blocks of mathematical Formula
1.9 Math spacing, vertically aligned material, Phantoms, Math font size, Theorems, Laws, Bold Symbols and list of mathematical symbols.
1.10 Bibliography, Indexing
1.11 The Verbatim Package
1.12 creating Presentations with the beamer class.

Unit II: Limit and continuity of functions of one variable

2.1 Introduction to the concept of limit
2.2 Rules for finding limits
2.3 Continuity of a function
2.4 Types of discontinuity

Unit III: Derivatives and Applications

3.1 Differentiability of a function
3.2 Relation between continuity and differentiability of a function
3.3 Implicit differentiation
3.4 Maximum and minimum values of a function
3.5 Greatest and least values of a function
3.6 Increasing or decreasing functions on an interval
3.7 First and second derivatives
3.8 Concavity
3.9 Optimization problems
3.10 Linearization of functions
3.11 Shapes and graphs of elementary functions

UNIT IV: Multivariable functions and partial derivatives

4.1 Functions of several variables
4.2 Limit and continuity of multivariable functions
4.3 Differentiable functions
4.4 Partial derivatives
4.5 Euler's theorem
4.6 Linearization of functions of two variables
4.7 Chain rules
4.8 Extreme values
4.9 Saddle points
4.10 Lagrange multipliers
4.11 Error formula for linear approximations

Unit V: Integration and Application

5.1 Integration by partial fraction
5.2 Integration by trigonometric substitution

5.3 Integration of rational functions
5.4 Integration of irrational functions
5.5 Definite integrals and its properties
5.6 Fundamental theorem of integral calculus
5.7 Area under a curve
5.8 Surface area and volume of revolution of a curve about a straight line
5.9 Relation between area under a curve and probability

Unit VI: Multiple Integrals

6.1 Double Integrals over rectangles
6.2 Iterated integrals
6.3 Double integral over general regions
6.4 Area in the plane using double integral
6.5 Double integral as volume
6.6 Double integral in polar form
6.7 Average value of a function of two variables
6.8 Change of variable in double integral
6.9 Definition of triple integral
6.10 Iterated integrals
6.11 Volume of a region in space using triple integral
6.12 Average value of a function in space
6.13 Jacobian
6.14 Change of variable in triple integra**l**

Reading List

Essential Reading

Oetiket, T., et al. (2005). The Not So Short Introduction to LaTeX. Free Software Foundation, Inc., 675 Mass Ave Cambridge, MA 02139, USA

Thomas, G.B and Finney, R.L. (2012). *Calculus and Analytic Geometry* (12th ed.) New Delhi: Dorling Kindersly (India) Pvt. Ltd.

Kreyszig, E. (2006). *Advanced Engineering Mathematics*. (8thedition). John Wiley and Sons.

Salas, S.L., Hille, E. & Etgen, G.J. (2003). *Calculus: One and Several Variables*. (9th edition). John Wiley and Sons.

Additional Reading

Apostal, T.M. (2005). *Calculus: Volume I*. John Wiley and Sons.

Spiegel, M.R. (1981). *Advanced Calculus*. (Schaum's Outline Series, Asian Student Edition). McGraw Hill Book Company.

Frank, A. Jr., & Mendelson, E. (1992). *Differential and Integral Calculus*. (Schaum's Outline series, 3rd edition). McGraw Hill Book Company.

Steward, J. (1999). *Calculus* (4th ed.) Singapore: Brooks/Cole Publishing Company.

Date: March, 2022

DST101: Descriptive Statistics

Module Code & Title: DST101 Descriptive Statistics
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
The objective of this module is to introduce the basic information about variables in a data set and emphasise the potential relationship between variables and descriptive statistical techniques that would help the students in understanding the importance and need of statistics. It would help them in understanding the concepts involved in data presentation, analysis, and interpretation using suitable statistical data and measures. Students are expected to use Spreadsheet Package during laboratory sessions.

Learning Outcomes
On completion of the module, students will be able to:

1. Define the basic concepts and scope of statistics.
2. Explain the descriptive statistical techniques and its scope in describing the real world problems.
3. Present data in a meaningful manner after the proper arrangement using Spreadsheet Package.
4. Interpret data using appropriate statistical measures using statistical functions.
5. Compute different measures from the data collected using statistical functions.
6. Evaluate the values of the different measures of dispersion by making use of an appropriate formula.
7. Calculate the moments from the datasets using statistical functions.
8. Measure the skewness of the datasets and interpret the “lack of symmetry” from the value computed.
9. Find the inter-class correlation of the datasets using Data Analysis Tools.

Teaching and learning approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory session	1	
Independent study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach
A. **Problem-solving Assignment (10%)**
Individual assignment will be given during the first half of the semester. The assignment will comprise of problem-solving based on the subject matters of Unit I and Unit II to assess the students’ ability in data representation skills, data visualizing skills and interpretation of descriptive statistics. The assignment will be assessed using following criteria:

- Correctness of the solutions: 40%
- Logical flow in the process: 20%
- Uniqueness of the solution: 20%
- Use of appropriate formulae and symbols: 20%
-

The final marks will be converted out of 10%.

B. **Laboratory Assessment (20%)**

Laboratory assessment will be carried out as follows:

- **Laboratory report- 5%**

Students will submit a weekly record of the laboratory session of 250-500 words to keep track of his/her progress. Each weekly report will be assessed for 5 marks. At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. The students will be required to submit minimum of 10-laboratory. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD. The laboratory report will be assessed using the following criteria:

- Objective: 1
- Methods: 2
- Results: 1
- Conclusions: 1

- **Laboratory Exam- 15%**

  A laboratory exam for the duration of 1 ½ hour will be conducted towards the end of the 13th week of regular teaching to assess their ability in describing and interpreting real world problems using Spreadsheet Package. Laboratory exam will be assessed using the following criteria:

- Correctness of the solutions: 40%
- Use of appropriate Spreadsheet functions/formulae/graphs 30%
- Inference on findings 30%
-

The final marks scored by the students will be converted out of 15%.

C. **Mid-Semester Examination (20%)**

Mid-semester examination will be conducted in the mid of the semester with at least 60% of the subject matters being covered for the duration of 2 ½ hours to evaluate their ability in interpreting descriptive statistics. The exam will be conducted out of 50 marks and the final marks will be converted out of 20%.

D. **Semester-end Examination (50%)**

Semester-end Examination will cover all of the subject matters for the duration of 2 ½ hours to evaluate their ability in interpreting descriptive statistics. The exam will be conducted out of 50 marks and the final marks will be directly taken into the account.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Problem-solving Assignment		1	10%
B. Laboratory Assignment	Laboratory report	10	5%
	Laboratory exam	1	15%
C. Mid-Semester Examination		1	20%
D. Semester-end Examination		1	50%

Prerequisite: None

Subject Matter

Unit I: Introduction and Data Presentation

1.1 Introduction
1.1.1 Definition and scope of Statistics
1.1.2 Descriptive statistics vs Inferential statistics
1.1.3 Concepts of statistical population and sample
1.1.4 Types of data: nominal, ordinal, interval and ratio
1.2 Data presentation
1.2.1 Frequency Distribution: type and construction of frequency distribution tables
1.2.2 Graphical representation of frequency distribution: Histogram, Frequency Polygon, Cumulative frequency curve or the Ogives and Lorenz curves.
1.2.3 Classification and tabulation
1.2.4 Charts
1.2.4.1 Pie chart
1.2.4.2 Bar chart and stacked bar chart
1.2.4.3 Column chart and stacked column chart

Unit II: Analysis of univariate data

2.1 Measures of central tendency
2.1.1 Mean, Median, and Mode and the Relationship between Mean, Median and Mode
2.1.2 Arithmetic mean, Geometric mean, Harmonic mean and their properties
2.1.3 Partition values: Quartiles, Deciles and Percentiles
2.2 Measure of dispersion
2.2.1 Measures of location
2.2.2 The Range, Quartile Deviation and Mean Deviation
2.2.3 Variance and Properties of Variance
2.2.4 Standard Deviation and Application of Standard Deviation
2.2.5 Concept of dispersion, Absolute and Relative measures of dispersion, Requirements of a good measure of dispersion.
2.2.6 Relationship between the measures of dispersion
2.2.7 Coefficient of variation.
2.2.8 Moment generating function, characteristic function, cumulant generating, function
2.2.8.1 their properties
2.2.8.2 moments
2.2.8.3 measures of locations
2.2.8.4 dispersion
2.2.8.5 Skewness and Kurtosis for discrete and continuous variates.

Unit III: Analysis of bivariate data

3.1 Bivariate data and scatter diagram
3.2 Covariance and properties
3.3 Simple correlation and properties
3.4 Computation of correlation coefficients: Pearson, Kendall, Spearman
3.5 Measure of correlation ratio
3.6 Concept of intra-class correlation, and its interpretation.
3.7 Simple linear regression
3.8 Properties of regression coefficients
3.9 Derive expressions for partial and multiple correlation coefficients and regression coefficients, and discuss the interrelationship between them.

Unit IV: Theory of attributes

4.1 Fundamental set of frequencies; notations, classes, class frequencies and order of classes

4.2 Conditions for consistency of data
4.3 Examine consistency of data
4.4 Contingency table
4.5 Derive criteria for independence of attributes
4.6 Association of attributes
4.7 Computation of measures of associations:
    4.71 Yule's coefficient of association
    4.72 Coefficient of colligation
4.8 Establish relationship between Yule's coefficient of association and coefficient of colligation.

List of Laboratory Sessions

1. Construction of univariate and bivariate frequency distributions with samples of size not exceeding 200 using COUNTIFS () / FREQUENCY () functions and Pivot Table tool.
2. Diagrammatic and Graphical representation of data and Frequency distributions - Pie diagram, Bar diagram, Multiple Bar diagrams, Sub divided Bar diagrams, percentage bar diagrams, Line diagram, Frequency polygon, Frequency curve, Histogram, Ogives, Lorenz curves.
3. Numerical computations of measures of location and dispersion (absolute and relative) moments, measures of Skewness and Kurtosis for both grouped and ungrouped data - Sheppard's correction for grouped data using the following functions:
   AVERAGE (), MEDIAN (), MOD (), STDEV (), SLOPE (), INTERCEPT (), SKEW (), and KURT ().
4. Fitting of first degree, second degree and exponential curves by method of least squares using Data Analysis Tools.
5. Computation of correlation coefficient, regression lines for raw and grouped data. Rank correlation coefficient, linear predictions using CORREL (), PEARSON (), and FORECAST () functions.
6. Computation of partial regression, partial correlation and multiple correlation coefficients given total correlation coefficients (involving 3 variables) using Data Analysis Tools.
7. Construction of contingency tables using Pivot tables and testing the consistency of data.
8. Computations of various measures of association of attributes using Table tool.

Reading list

Essential Reading

Miller, I., Miller, M., & Freund, J. E. (2014). *John E. Freund's mathematical statistics with applications*. Boston: Pearson.

Goon, A. M., Dasgupta, B., & Gupta, M. (1991). *Fundamentals of Statistics Vol. 1*. The world press.

Gupta, S. P. (2002): *Statistical Methods.* Sultan Chand and Sons, New Delhi.

Linneman, T. J. (2021). *Social Statistics Managing Data, Conducting Analyses, Presenting Results*. Taylor and Francis Group.

Additional Reading

Gupta, S. C., and Kapoor, V. K. (2007). *Applied Statistics*, Sultan Chand and Sons, New Delhi.

Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of mathematical statistics*. Sultan Chand & Sons.

Hogg, R. V., and Criag, A. T. (2013). *Introduction to Mathematical Statistics*, Macmillan Publishing, New York.

Mood, A. M., Graybill, F. A., and Bose D. C. (2001). *Introduction to the theory of Statistics*, Tata McGraw Hill, New Delhi.
Sheldon, R. (2007). *Introduction to Probability Models*, Academic Press, New Delhi.
Walpole, R. E., Myers, R. H., Myers S. L., and Ye, K. (2001). *Probability and Statistics for Engineers and Computer Scientists*, Prentice Hall, New Delhi.

Date: Date: March, 2022

ALG107: Set Theory and Theory of Equations

Module Code & Title: ALG107 Set Theory and Theory of Equations
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: R. Balamurugan

General Objective

This module introduces the basic concepts of set theory and functions which are required for the study of probability in the later semesters. Properties of natural number system help the students use principle of mathematical induction to state and provide full proof of identities and theorems which are true for all positive integers. Theory of equations will help the students solve cubic and biquadratic equations under given conditions. All these fundamental concepts help them in developing their analytical and problem-solving skills

Learning Outcomes

On completion of the module, students will be able to:

1. Define sets, subsets, power sets in their own words with examples.
2. Apply different concepts of sets like cardinality, ordered pairs and Cartesian products.
3. Define different types of relations and functions in their own words with examples.
4. Identify whether the given relation is reflexive, symmetric, antisymmetric or transitive.
5. Find all the equivalence classes of a relation.
6. Determine whether a given function is surjective, injective or bijective.
7. Use principle of mathematical induction to prove results which are true for all positive integers.
8. Determine relation between roots and coefficients of the equation.
9. Find roots of the equation with the given conditions.
10. Express a given symmetric function of roots in terms of elementary symmetric functions and evaluate their values.
11. Apply De Moivre's Theorem to find the roots of polynomial equations.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent Study	Assignments/ VLE Quizzes	2	**60**
	Self-study	2	
Total			**120**

Assessment Approach

A: Assignments/VLE quizzes: (40%)

Three continuous assessment components will be given to the students:
First will be carried out after completing first three units of the subject matter and the portion of final marks will be 10%. Second will be carried out after completing the last two units and the portion of final marks will be 15%. Third will be on the whole of the subject matter and the portion of final marks will be 15%.

These can be either a written assignment of five questions randomly selected from pre-disclosed sets of practice questions provided to the students in advance or a group assignment (a group will have only two randomly selected members) with same type of five questions or a VLE quiz on the subject matter of respective units.

In case of written assignments, every student/group has to solve the questions and submit in one hour during one of the tutorial classes. Grading of written assignments will be done based on the procedure and correctness of solution submitted by the students.

VLE quiz will have to be attempted individually and will be of one-hour duration. A student will have to choose a different type of assessment component each time in consultation with the module tutor.

B: Open-book Problem Solving: (10%)

This assessment will be carried out after completion of all the units. A set of five questions – one from each unit of the subject matter – will be provided to the students. Each student is expected to solve them independently and submit the solution in an hour. They are free to refer to their class notes while solving. Grading will be done based on the procedure and correctness of solution submitted.

C: Semester-end Examination: (50%)

Semester end Examination for 50 marks will be conducted for the duration of two and a half hours and questions will be from all the units of the subject matter. Test blue print of the question paper and marking scheme for grading will also be prepared along with the question paper.

Overview of Assessment Approaches

Areas of assessments	Quantity	Weighting
A. Assignments/VLE quiz	3	40%
B. Open-book Problem Solving	1	10%
C: Semester-end- Examination	1	50%

Prerequisite: None

Subject Matter

Unit I: Set theory

1.1 Definition and examples of:
- 1.1.1 Sets and equality of sets
- 1.1.2 Subsets
- 1.1.3 Complements of a subset
- 1.1.4 Properties of complement of a subset
- 1.1.5 De Morgan’s laws and their proof

1.2 Cardinality of sets, Power set

1.3 Union and intersection of sets
    1.3.1 Commutativity of union and intersection
    1.3.2 Associativity of union and intersection with proof
    1.3.3 Distributive property of union over intersection and intersection over union
1.4 Set difference
    1.4.1 Definition and examples
    1.4.2 Non-commutativity of set difference
    1.4.3 Non-associativity of set difference
1.5 Symmetric difference of two sets
    1.5.1 Commutativity of symmetric difference
    1.5.2 Associativity of symmetric difference

Unit II: Relations and functions

2.1 Ordered pairs, Cartesian product
2.2 Relations, equivalence relations
2.3 Equivalence classes
    2.3.1 Disjointness
    2.3.2 Exhaustiveness
    2.3.3 Partition
2.4 Definition and examples of Functions
2.5 Injective, surjective and bijective functions
2.6 Composition of functions
    2.6.1 Associative property of composition
    2.6.2 Non-commutativity of composition
2.7 Invertible functions

Unit III: Natural number system

3.1 System of natural numbers
3.2 Well ordering principle
3.3 Division algorithm
3.4 Divisibility and Euclidean algorithm
3.5 Congruence relation and its properties with proof
3.6 System of linear congruences and Chinese remainder theorem
3.7 Principle of mathematics induction
3.8 Fundamental theorem of Arithmetic with proof

Unit IV: Theory of equation

4.1 Polynomial equations
4.2 Multiplication of Polynomials
4.3 Division algorithm
4.4 Algebraic equation
4.5 Factor Theorem with proof
4.6 Fundamental theorem of algebra (without proof)
4.7 Formation of equations (up to degree 4) when roots are given
4.8 Relation between roots and coefficients of an equation
4.9 Solving equation (up to degree 4) when
    4.9.1 Sum of two roots is given
    4.9.2 Product of two roots is given
    4.9.3 One root is a multiple of another
    4.9.4 Roots are in arithmetic progression
    4.9.5 Roots are in geometric progression

4.9.6 Roots are in harmonic progression
4.10 Symmetric function of the roots of an equation
4.10.1 Elementary symmetric functions
4.10.2 Other symmetric functions of roots (up to degree 4)
4.10.3 Expression of other symmetric functions in terms of elementary symmetric functions
4.10.4 Finding values of symmetric functions of roots
4.11 Transformation of equations

Unit V: De Moivre's theorem
5.1 De Moivre's theorem for integral and rational index
5.2 Summation of Trigonometric series
5.2.1 Using method of differences
5.2.2 Using De Moivre's theorem for series with sine or cosine of angles in arithmetic progression
5.3 Solution to polynomial equations using De Moivre's theorem.

Reading List
Essential Reading
Pinter, Charles C. (2014). *A Book of Set Theory*. New York: Dover Publications. Inc.

Arumugam. S & Issac. A. T. (2015). *Modern Algebra.* Chennai: Scitech Publications (India) Pvt. Ltd.

Manickavachagom Pillai. T. K. & Natarajan. S. (2009). Algebra I. Chennai: Viswanathan Printers and Publishers.

Additional Reading
Rosen, K. (2011). Discrete Mathematics and Its Applications (7th ed.). New York: McGraw-Hill Science/Engineering/Math.

Singal, M.K. & Singal, A.R. (2006). Mathematics for Physical Sciences. New Delhi: R. Chand & Co.

Date: December, 2021

PLT102: Programming in Python

Module Code & Title: PLT102 Programming in Python
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Sangay Thinley

General Objective
This module introduces the fundamental principles of computer programming in Python. Students will learn how to use Python programming language for writing simple programs and for data analysis. Further, the module will prepare the students to use other special-purpose programming languages like R for use in solving statistical problems and data analysis.

Learning Outcomes

On completion of the module, students will be able to:

1. Draw flow charts based on algorithms for computer programs.
2. Design and program simple applications using Python.
3. Apply loop structures and Booleans to navigate through Python programming structures.
4. Outline the purpose and application of loops and decision statements.
5. Employ functions in Python for reuse.
6. Import data from online sources.
7. Describe the core objects of Python, such as strings, lists, tuples and dictionaries.
8. Compute statistical measures using Python.
9. Write simple object-oriented program in Python.
10. Import useful modules from the Internet and create one's own modules.
11. Store and manipulate data using NumPy library
12. Manipulate data using Pandas library
13. Determine the correct use of Numpy or Pandas based on a condition

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**90**
	Laboratory session	3	
Independent Study	Self-study	2	**30**
Total			**120**

Assessment Approach

A. VLE quiz: 5%

VLE quiz (with 20 multiple-choice questions worth 20 marks) will be conducted after the mid-semester examination with at least 80% of the subject matters being covered and before laboratory examination for a duration of 30 minutes. The marks obtained will then be converted to 5%.

B. Lab Assessment: 35%

Lab Assessment will be assessed based on the following components:

- Laboratory Assignments: 15%.
- Laboratory Examination: 10%
- Viva Voce: 10% (Laboratory assignments: 7%, Laboratory examination: 3%).

Laboratory Assignments (a total of 10 with one assignment for first three units and one each for remaining units) will be based on the concepts taught in the theory class. Students will be provided a set of programming questions every week covering the concepts taught on each unit. The students will have to submit the solutions at the end of the lab session through the VLE.

The following rubrics will be used to assess the set of programming questions. Each set will be assessed out of 100 marks and converted to 1.5%.

Program (100)	**(Excellent) 100-81%**	**(Good) 80-61%**	**(Satisfactory) (60-41% of the points)**	**(Unsatisfactory) (<=40% of the points)**
Requirements and Delivery (50 points)	• Completed between 90-100% of the requirements.	• Completed between 80-90% of the requirements.	• Completed between 70-80% of the requirements.	• Completed less than 70% of the requirements.

	• Delivered on time, and in correct format.	• Delivered on time, and in correct format.	• Delivered on time, and in correct format.	• Delivered on time but not in correct format.
Program execution (20 points)	• Executes without errors excellent user prompts, good use of symbols, spacing in output. • Thorough and organized testing or input validation has been completed.	• Executes without errors. • User prompts are understandable, minimum use of symbols or spacing in output. • Most testing or input validation completed.	• Executes without errors. • User prompts contain little information, poor design. • Some testing or input validation has been completed.	• Does not execute due to errors. • User prompts are misleading or non-existent. • No testing has been completed, or no input validation.
Design of logic (10 points)	• Program is logically well designed.	• Program has slight logic errors that do no significantly affect the results	• Program has significant logic errors.	• Program is incorrect.
Coding Standards (10 points)	• Includes name, date, and assignment title. • Excellent use of white space. • Creatively organized work. • Excellent use of variables (no global variables, unambiguous naming).	• Includes name, date, and assignment title. • Good use of white space. • Organized work. • Good use of variables (no global variables, unambiguous naming)	• Includes name, date, and assignment title. White space makes program fairly easy to read. • Organized work. • Good use of variables (few global variables, unambiguous naming).	• No name, date, or assignment title included. • Poor use of white space (indentation, blank lines). • Disorganized and messy. • Poor use of variables (many global variables, ambiguous naming).
Documentation (10 points)	• Clearly and effectively documented including descriptions of all class variables. • Specific purpose noted for each function, control structure, input requirements, and output results.	• Clearly documented including descriptions of all class variables. • Specific purpose is noted for each function and control structure.	• Basic documentation has been completed including descriptions of all class variables. • Purpose is noted for each function.	• Very limited or no documentation included. • Documentation does not help the reader understand the code.

Laboratory examination will be conducted after the completion of the module and before semester-end examination and will cover all the units. Each student will be given two questions and will be graded out of 100 based on the rubric mentioned above. The marks obtained will then be converted out of 10%.

Viva voce for the laboratory assignments will be conducted at least two times to assess the students' understanding of the laboratory assignments. Viva voce will also be conducted for the laboratory examination. The following rubrics will be used for viva voce. Each viva voce (maximum 5 minutes per student) will be assessed out of 100 marks and converted to 7% for laboratory assignments and 3% for lab examination respectively.

Program (100)	**(Excellent) 85-100%**	**(Good) 61-84%**	**(Satisfactory) (<=60% of the points)**
Knowledge in programming (50 points)	Demonstrates deep knowledge, answer the questions with explanation and elaboration.	Adequate knowledge of most topics, answer the questions but fails to elaborate.	Superficial knowledge of topic, only able to answer basic questions.
Problem-solving ability (30 points)	Efficient mapping of theory concepts with practical problem solving approaches.	Moderate mapping of theory concepts with practical problem solving approaches.	Improper mapping of theory concepts with practical problem solving approaches.
Critical Thinking (20 points)	Can predict and defend problem outcomes.	Approximately predicts and defends problem outcomes.	Is unable to predict problem outcomes for the given input data set.

C. Mid-Semester Examination: 10%

Mid-semester Examination will be conducted (out of 40) in the mid of semester with at least 60% of the subject matters being covered for the duration of 2 hours. The marks obtained will then be converted out of 10%.

D. Semester-end Examination: 50%

Semester end Examination for the duration of two and half hours will be conducted. The exam will be conducted out of 50.

Overview of Assessment Approaches and Weighting

Areas of Assignments		**Quantity**	**Weighting**
A. VLE Quiz		1	5%
B. Laboratory Assessment	Laboratory assignments	10	15%
	Laboratory examination	1	10%

	Viva-voce	3	10%
C. Mid-Semester Examination		1	10%
D. Semester-end Examination		1	50%
Total			100%

Prerequisite: None

Subject Matter

Unit I: Fundamentals of Programming

1.1 Algorithm Basics
1.2 Flow Chart
1.3 Introduction to Programming
1.4 Programming Languages

Unit II: Introduction to Python

2.1 Software Development Process
2.2 Write Simple Python Program
2.3 Output Statements
2.4 Elements of Programs
2.5 Definite Loops

Unit III: Variables, expressions and statements

3.1 Values and Types
3.2 Variables
3.3 Variable names and Keywords
3.4 Statements
3.5 Evaluating Expressions
3.6 Operators and operand
3.7 Order of operations
3.8 Operations on Strings
3.9 Composition
3.10 Comments

Unit IV: Defining Functions

4.1 Function of Functions
4.2 Recursive functions
4.3 Arguments
4.4 Return values
4.5 Local Variables
4.6 Functions that Modify Parameters
4.7 Functions and Program Structure

Unit V: Iteration and Conditional Execution

5.1 If-Else Statement
5.2 For Loops
5.3 While Loops
5.4 Indefinite Loops
5.5 Common Loop Patterns
5.6 Computing with Booleans
5.7 Other Common Structures

Unit VI: Strings

6.1 Concatenation and repetition
6.2 Indexing
6.3 Slices
6.4 Looping
6.5 String Methods
6.6 Escape Characters

Unit VII: Data Collections
7.1 Lists and Arrays
7.2 List Operations
7.3 Statistics with Lists
7.4 List of Records
7.5 Designing with Lists and Classes

Unit VIII: Dictionaries
8.1 Dictionary examples
8.2 Working with dictionaries
8.3 Counting words

Unit IX: Objecting-Oriented Programming with Python
9.1 Creating your own classes
9.2 Inheritance
9.3 Polymorphism
9.4 Method Overloading and Overriding
9.5 Examples (Tic-tac-toe)

Unit X: Modules
10.1 Importing Modules
10.2 Dates and Times
10.3 Working with files and directories
10.4 Zip Files
10.5 TXT Files
10.6 Getting files from the Internet
10.7 Creating your own modules
10.8 HTTP Protocol (request and response)
10.9 JSON

Unit XI: Introduction to NumPy
11.1 Understanding Data Types in Python
11.2 The Basics of NumPy Arrays
11.3 Computation on NumPy Arrays: Universal Functions
11.4 Aggregations; Comparisons
11.5 Masks, and Boolean Logic
11.6 Fancy Indexing; Sorting Arrays
11.7 Structured Data

Unit XII: Data Manipulation with Pandas
12.1 Introducing Pandas Objects
12.2 Data Indexing and Selection
12.3 Operating on Data in Pandas
12.4 Handling Missing Data

12.5 Hierarchical Indexing
12.6 Juggling between Numpy and Pandas, Knowing when to use Numpy and Pandas

List of Laboratory Sessions

1. Program to use operators and operand
2. Program to swap two variables
3. Program to find factorial of a number (including recursion)
4. Program to make a calculator
5. Program to work with dictionaries (e.g. merge two dictionaries)
6. Program to apply string methods
7. Program to demonstrate difference between lists and arrays
8. Program to implement inheritance and polymorphism
9. Programs to implement Pandas data frame
10. Programs to implement NumPy arrays
11. Program to import and use modules (including downloading files from the Internet)
12. Program to create Python dictionary from JSON response

Reading List:

Essential Reading

Deitel, P., Deitel, J. (2019*). Introduction to Python for Computer Science and Data Science Learning to Program with AI, Big Data and the Cloud*. Pearson.

Heinold, B. (2012). *A Practical Introduction to Python Programming.* Creative Commons Attribution-Noncommercial-Share Alike 3.0 Unported License.

VanderPlas, J. (2016). *Python Data Science Handbook*. OReilly

Zelle, J.M. (2017). *Python programming: An Introduction to Computer Science* (3rd.). Tom Sumner.

Additional Reading

Lutz, M. (2013). *Learning Python* (5th ed.). OReilly.

Rao, R. N. (2017). *Core python programming*. Dreamtech press.

Sedgewick, R., Wayne, K., & Dondero, R. (2015). *Introduction to programming in Python: An interdisciplinary approach*. Addison-Wesley.

Date: March, 2022

Year 1: Semester II

DST102: Probability Theory

Module Code &Title: DST102 Probability Theory
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

Important concepts on random experiments, sample space, different events, sets, random variables and distribution functions will be taught in this module. It will discuss the different modes of convergence of sequences of random variable. The students are also exposed to convergence

in distribution, culminating in the central limit theorem, strong law of large numbers. There is also application of this theory in various decision-making problems especially under uncertainties. Students are expected to use Spreadsheet Package during laboratory sessions.

Learning Outcomes

On completion of the module, students will be able to:

1. Distinguish between probability models appropriate to different chance events.
2. Obtain the solution of the real world problems based on probability space and limit theorems using Spreadsheet Package.
3. Find the solution to the problems based on random variables and distribution functions.
4. Figure out the solution of the problems based on moment generating function for discrete and continuous distributions using Spreadsheet Package.
5. Draw the solution of the problems based on characteristics generating function for discrete and continuous distributions using Spreadsheet Package.
6. Apply probability theory in real life problems
7. Differentiate the different forms of convergence.
8. Determine the random variable from the given sample space.
9. Compute the distribution function of random variables.
10. Write the moment generating function of a random variable.
11. Derive the characteristics function of a random variable.

Learning and teaching approaches

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment:(10%)**

Individual assignment will be given during the first half of the semester to assess students' ability in finding solutions of the problems based on random variables and distribution functions. The assignment will comprise of problem solving based on some questions from Unit I through Unit III. Assignments will be assessed using marking criteria.

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

B. **Laboratory Assignment:(20%)**

Laboratory assignment will be carried out as follows:

- **Laboratory report: 5%**

Students will submit weekly record of the laboratory sessions to keep track of his/her progress. The first submission will be in the 3rd week and last submission in the 14th week of teaching. A total of 12 reports will be submitted for evaluation. Each report will be assessed out of 5 marks

which makes a total of 60 marks for 12 reports. Marks scored out of 60 will be then converted to account for 5% of the total module grade. It will be evaluated based on the following rubric:

Proficient (3.5-5)	Adequate (2-3.5)	Substandard (0.5-2)	Unacceptable (0-0.5)
Student demonstrates an accurate understanding of the laboratory objectives and concepts. Questions are answered completely and correctly. Errors, if any are minimal	Student has a basic knowledge of content, but may lack some understanding of some concepts. Questions are answered fairly well.	Student has problems with both the graphs and the answers. Student appears to have not fully grasped the laboratory content.	Students turns in laboratory report late or the report is incomplete and/or inaccurate.

- **Laboratory Exam: 15%**

A laboratory exam for the duration of 1 ½ hour will be conducted towards the end of the 13th week of regular teaching to assess students' ability in solving real world problems using Spreadsheet Package. The laboratory exam will be out of 50 marks which will be converted to account for 15% of the total module grade. This exam will cover all the topics covered in the laboratory sessions conducted over the entire semester.

C. **Mid-Semester Examination: (20%)**

Mid-semester examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for a duration of 2 ½ hours to evaluate students' ability in computing the solution of problems based on the coverage of subject matter. This exam will be out of 50 marks and the marks scored by the students will be converted to account for 15% of the total module grade.

D. **Semester-end Examination: (50%)**

Semester-end examination will cover all the subject matter from unit I till unit V. It will be conducted for a duration of 2 ½ hours. Students will write the exam for 50 marks which will directly account for the final 50% of total module grade.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Laboratory Assignment	Laboratory Report	12	5%
	Laboratory Exam	1	15%
C. Mid-Semester Examination		1	20%
D. Semester-end Examination		1	50%

Prerequisite: None

Subject Matter

Unit I: Combinatorial Analysis

1.1 Basic counting principles:

1.1.1 Pigeonhole principle.
1.1.2 Rule of sum.
1.1.3 Rule of product.
1.1.4 Double counting.
1.2 Permutations.
1.3 Arrangements.
1.4 Combinations.
1.5 Binomial Theorem without proof.
1.6 Multinomial Coefficients.

Unit II: Probability Space and Stochastic convergence

2.1 Probability Space:
2.1.1 Elements of measure theory.
2.1.2 Probability - classical and frequency definitions, axiomatic approach.
2.1.3 Some simple properties.
2.1.4 Discrete probability space.
2.1.5 Induced probability space.
2.1.6 Other measures-Complements and problems.
2.1.7 Conditional probability and Bayes' theorem.
2.1.8 Class of sets, field, sigma field, minimal sigma field, Borel sigma field in R.
2.2 Stochastic Convergence:
2.2.1 Almost sure convergence.
2.2.2 Convergence in probability.
2.2.3 Convergence in distribution.
2.2.4 Dominated Convergence Theorem.
2.2.5 IID and Non-IID stochastics variables.
2.2.6 Fatou's Lemma without proof.
2.2.7 Weak law of large numbers.
2.2.8 Strong law of large numbers.
2.2.9 Borel –Cantelli lemma without proof.
2.2.10 Limiting moment generating functions.
2.2.11 Central limit theorem: Demoviere- Laplace, Lindberg – Levy, Liapounov. (Without Proof)
2.2.12 Definition of quantiles and statement of asymptotic distribution of sample quantiles.
2.2.13 Kolmogorov Maximal inequality (Without Proof).

Unit III: Random variables and Distribution Functions

3.1 Random variables.
3.2 Function of random variables.
3.3 Probability mass functions.
3.4 Probability density functions.
3.5 Distribution function and its properties.
3.6 Conditional probability and expectation.
3.7 Cauchy- Schwartz and Chebyshev inequalities (Without Proof)

Unit IV: Properties of Expectations

4.1 Expectations of sums of random variables.
4.2 Covariance.
4.3 Variance of sums, and correlations.
4.4 Conditional expectations.

Unit V: Applications of mgf and cf for distributions

5.1 Mathematical expectation and moments.
5.2 Probability generating function (PGF).
5.3 Moment generating function (MGF).
5.4 Characteristic function (CF): Definition and simple properties.

List of Laboratory sessions

1. Estimate the probabilities with data set using PROB () function in Excel.
2. Find the expectation of random variables from the data using SUMPRODUCT () function in Excel.
3. Calculate the conditional probabilities from the data using statistical functions in Excel.
4. Verify the Chebyshev's inequality through data using formulae in Excel.
5. Demonstrate the stochastic convergence in Excel.
6. Evaluate the pgf, mgf, and cf of distribution in Excel.

Reading Lists

Essential Reading

Capinski, M., & Zastawniak, T. J. (2013). *Probability through problems*, Springer Science & Business Media, Berlin.

Durrett, R. (2019). *Probability: Theory and examples* (Vol. 49), Cambridge University press, Cambridge.

Ash, R. B., Robert, B., Doleans-Dade, C. A., & Catherine, A. (2011). *Probability and measure theory*, Academic Press, Cambridge.

Rohatgi, V. K., & Ehsan, S. (2015). *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Private Ltd., New Delhi.

Additional Reading

Devore, J. L., & Berk, K. N. (2012). *Modern mathematical statistics with applications*, Springer, New York.

Dudewicz, E. J., & Mishra, S. (1988). *Modern mathematical statistics*. John Wiley & Sons, New Delhi

Rohatgi, V. K., & Saleh, A. K. Md. E. (2015). *An Introduction to Probability and Statistics*, John Wiley, New Delhi.

Date: March, 2022

CAL206: Differential Equations I

Module Title: Differential Equations – I
Module Code: CAL206
Programme: BSc in Mathematics
Credit Value: 12
Module Tutor: Samten Choden

General Objective

The General purpose of this module is to provide the necessary skill to solve ordinary differential equations using different methods. The module aims at developing learner's techniques to express relationships between changing quantities and their applications in physical and other situations.

Learning Outcome

On completion of the module, students will be able to:

- Classify an ordinary differential equation in terms of its order, independent and dependent variables.
- Recognize a separable, exact and linear ODE and solve by appropriate method.
- Explain the difference between the general solution and unique solution of an initial valued problem.
- Analyze and interpret the mathematical result in terms of the original physical problems.
- Explain the difference between homogeneous and non-homogeneous ODE.
- Solve different types of Ordinary Differential Equations
- Perform a Laplace transform.
- Evaluate a non-homogeneous second order initial value problem using Laplace transform.

Learning and teaching approaches

Approach	Hours per week	Total credit hours
Lecture	4	60
Tutorial	1	15
Written assignment/Quizzes	1	15
Independent Study	2	30
Total		120

Lectures will be delivered in a conventional mode and occasional power point presentation and video lectures from well-known universities will be shown at least twice. During tutorials, the learners will be divided in to smaller groups of 4 each and they will be asked solve problems in consultation with their group members.

Assessment Approach

A: Assignments: Portion of Final marks: (20%)
Two major written assignments will be given in a semester. In written assignments, a set of problems/Theorems (Not over 10) spread over at least 50% of the subject matter will be given to the learners, which are to be solved by the students independently. (S)he may be called to attend a viva-voce to justify his work.

B: Mid-Semester Examination: The portion of final mark: (20%)
Mid-term examination will be of three hours duration with at least 50% of the subject matter.

C: Semester-end Examination: Portion of Final Mark: (60%)
Semester end Examination for the duration of three hours.

Overview of Assessment Approaches

Areas of assignments	Quantity	Weighting
A. Assignment	2 Assignment	20%
B. Mid-Semester Examination	1	20%
C. Semester-end- Examination	1 Exam	60%

Subject Matter

Unit I: First Oder Differential Equation

1.1 Basic concepts and ideas
1.2 Geometrical meaning of y'=f(x,y).
1.3 Separable equations, Exact equations
1.4 Linear Equations.
1.5 Examples on application to problems on growth and decay, heating and cooling, etc.
1.6 Initial value problems.

Unit II: Linear Differential Equation of Second Order
2.1 Homogeneous linear equations of second order
2.2 Second order homogeneous equations with constant coefficients
2.3 Characteristic equation
2.4 Complementary solutions and particular integral
2.5 General solutions
2.6 Use of differential operators
2.7 Euler-Cauchy equations
2.8 Existence and uniqueness theorem of solutions
2.9 Linear independence of solutions
2.10 Wronskian
2.11 Non-homogeneous equations
2.12 Solutions by methods of undetermined coefficients and variation of parameters.

Unit III: Linear Differential Equation of Third and Higher Order
3.1 Third order Euler-Cauchy equations
3.2 Third and fourth order homogeneous linear equations with constant coefficients
3.3 Non-homogeneous equations
3.4 Initial value problems.

Unit IV: Simultaneous Differential Equation
4.1 Solution of equations of the form: dx/dt + ax + by = f(t), dy/dt+cx+dy = g(t) and
4.2 Solution of equations of the form: dx/P = dy/Q = dz/R

Unit V: Total Differential Equation
5.1 Total differential equations and its conditions of integrability
5.2 Solution of Pdx + Qdy + Rdz = 0 by inspection
5.3 Solution of Pdx + Qdy + Rdz = 0, by taking one variable as a constant and
5.4 Solution of homogenous equations.

Unit VI: Laplace Transform
6.1 Laplace transforms
6.2 Properties of Laplace transforms (Linearity Property, first shifting property, transform of derivatives and integrals, second shifting property)
6.3 Unit step function
6.4 Dirac's Delta function
6.5 Laplace transform for periodic functions
6.6 Inverse Laplace transform
6.7 Properties of inverse Laplace transform
6.8 Inverse by partial fraction method
6.9 Convolution theorem
6.10 Solution of differential equations

6.11 Solution of system of differential equations
6.12 Integral equations of convolution type

Reading List
Essential Reading
Kreyszig, E. (2011). *Advanced Engineering Mathematics*. (10th edition). New Delhi: John Wiley & Sons.
Raisinghania, M. D. (2005). *Ordinary and Partial Differential Equations*. (8th edition). New Delhi: S. Chand & Company Private Limited.

Additional Reading
Shepley L. Ross. (2007). *Differential Equations*. (3rd edition). Singapore: John Wiley & Sons.
Coddington, E A. (1988). *Introduction to Ordinary Differential Equations.* New Delhi: Prentice Hall India.
Wylie. C R. (1985). *Differential Equations*. New Delhi: McGraw Hill

Date: 6th March, 2017

ADS101: Data Structures and Algorithms

Module Code & Title: ADS101 Data Structures and Algorithms
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Karma Dorji

General Objective
Main objective of this module is to provide comprehensive knowledge of modern computer algorithms and solving scientific and engineering problems efficiently and accurately using appropriate data structures. Students will be guided how to analyze algorithms comparing efficiency of these algorithms. Python will be used as software platform for delivery under teaching and learning.

Learning Outcomes
On completion of the module, students will be able to:
1. Distinguish between primitive and non-primitive data types.
2. Find complexity of an algorithm using mathematical tools like big-O notations, Θ notations etc.
3. Implement stack ADT (Abstract Data Type) using arrays and linked lists.
4. Implement queue ADT using arrays and linked lists to solve real world problem.
5. Distinguish elementary sorts such as insertion and selection sort.
6. Describe the shortcomings of brute-force algorithms.
7. Identify practical example for brute-force, greedy, divide-and-conquer, and dynamic programming strategies.
8. Implement the various sorting algorithms.
9. Solve problems using fundamental graph algorithms.

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**75**

	Laboratory Session	2	
Independent Study	Self-study	2	**30**
	Assignment	1	**15**
Total			**120**
Type	**Approach**	**Hours per week**	**Total credit hours**
Contact	Lecture	3	**75**
	Laboratory Session	2	
Independent Study	Self-study	2	**30**
	Assignment	1	**15**
Total			**120**

Assessment Approach

A. Assignment: (10%)

The written assignment will be administered during the first half of the semester after completion of 30 percent of the syllabus content. This individual assignment will require the student to solve a real-world algorithmic problem. Assessment will be done based on the following criteria:

1. Correctness of the result (3%)
2. Algorithm chosen to solve the problem (2%)
3. Data structure used to solve the problem (2%)
4. Logic (3%)

B. Lab Assessment: (30%)

Lab assignment exercises will test the skill of the students that comply with learning outcome. Lab assignment will be assessed based on the following components

- Weekly lab report submissions:10%
    - The learners will have to submit a lab report after every practical lab session. The lab report will be a reflection of what the learners have learnt during the practical lab sessions.

C. Laboratory Assessment: (30%)

Laboratory assignment exercises will test the skill of the students that comply with learning outcome. Laboratory assignment will be assessed based on the following components

- Weekly laboratory report submissions:10%
    - The learners will have to submit a lab report after every practical laboratory session. The laboratory report will be a reflection of what the learners have learnt during the practical laboratory sessions.
- Laboratory examination: 15%
    - A laboratory examination of 3 hours will be conducted at the end of the semester. The laboratory exam will be a practical exam, based on the topics covered during the entire semester.
    -
- Viva-voce :5%
    - Communication skills 1
    - Knowledge in topics discussed 2

- Problem solving: Mapping of theory concepts with practical problem solving 2
- A laboratory examination of 3 hours will be conducted at the end of the semester. The laboratory exam will be a practical exam, based on the topics covered during the entire semester.

The following rubrics will be used to assess the set of programming task of the laboratory examinations. Each set will be assessed out of 100 marks and converted to 1.5%.100 marks and converted to 1.5%.

Program (100)	**(Excellent) 100%**	**(Good) 80%**	**(Satisfactory) (60% of the points)**	**(Unsatisfactory) (<=40% of the points)**
Requirements and Delivery (50 points)	• Completed between 90-100% of the requirements. • Delivered on time, and in correct format.	• Completed between 80-90% of the requirements. • Delivered on time, and in correct format.	• Completed between 70-80% of the requirements. • Delivered on time, and in correct format.	• Completed less than 70% of the requirements. • Delivered on time but not in correct format.
Program execution (20 points)	• Executes without errors excellent user prompts, good use of symbols, spacing in output. • Thorough and organized testing or input validation has been completed.	• Executes without errors. • User prompts are understandable, minimum use of symbols or spacing in output. • Most testing or input validation completed.	• Executes without errors. • User prompts contain little information, poor design. • Some testing or input validation has been completed.	• Does not execute due to errors. • User prompts are misleading or non-existent. • No testing has been completed, or no input validation.
Design of logic (10 points)	• Program is logically well designed.	• Program has slight logic errors that do no significantly affect the results	• Program has significant logic errors.	• Program is incorrect.
Coding Standards (10 points)	• Includes name, date, and assignment title. • Excellent use of white space.	• Includes name, date, and assignment title. • Good use of white space. • Organized work.	• Includes name, date, and assignment title. White space makes program fairly easy to read.	• No name, date, or assignment title included. • Poor use of white space (indentation, blank lines). • Disorganized and messy.

	• Creatively organized work. • Excellent use of variables (no global variables, unambiguous naming).	• Good use of variables (no global variables, unambiguous naming)	• Organized work. • Good use of variables (few global variables, unambiguous naming).	• Poor use of variables (many global variables, ambiguous naming).
Documentation (10 points)	• Clearly and effectively documented including descriptions of all class variables. • Specific purpose noted for each function, control structure, input requirements, and output results.	• Clearly documented including descriptions of all class variables. • Specific purpose is noted for each function and control structure.	• Basic documentation has been completed including descriptions of all class variables. • Purpose is noted for each function.	• Very limited or no documentation included. • Documentation does not help the reader understand the code.

D. Mid-Semester Examination: (10%)

Mid-Term examination of the duration of 2 hours will be conducted in the mid of semester with at least 50% of the subject matters covered. Test question paper will be of maximum 40 marks and converted to 10% of the total weightage.

Mid-semester examination of the duration of 2 hours will be conducted in the mid of semester with at least 50% of the subject matters covered. Test question paper will be of maximum 40 marks and converted to 10% of the total weightage.

E. Semester-end Examination: (50%)

Semester end Examination for the duration of two and half hours will be conducted 10% of the exam will comprise of topics covered during the mid-semester examination. 40% of the question will comprise from the topics covered after the mid-semester examination.

Overview of Assessment Approaches and Weighting

Areas of Assessments		**Quantity**	**Weighting**
A. Assignment		1	10%
B. Lab Assessment	Weekly lab report submission	1 per week	10%

	Lab examination	1	15%
	Viva-voce	2	5%
C. Mid-Semester Examination		1	10%
D. Semester-end Examination		1	50%
Total			100%
Areas of Assessments		**Quantity**	**Weighting**
E. Assignment		1	10%
F. Laboratory Assessment	Weekly lab report submission	1 per week	10%
	Lab examination	1	15%
	Viva-voce	2	5%
G. Mid-Semester Examination		1	10%
H. Semester-end Examination		1	50%
Total			100%

Prerequisite: PLT102 Programming in Python

Subject Matter

Unit I: Introduction to Data structure

1.1 Abstract Data Types (ADT)

1.1.1. Concepts with examples

1.2 Non-Primitive Data Structures:

1.2.1 Linear List

1.2.1.1 Stack

1.2.1.2 Queue

1.2.2 Non-linear List

1.2.2.1 Tree

1.2.2.2 Graph

Unit II: Sorting Algorithms

2.1 Insertion Sort

2.1.1 Illustration of method

2.1.2 Algorithm in pseudo-code

2.1.3 Complexity

2.1.4 Area of application

2.2 Merge Sort

2.2.1 Illustration of method

2.2.2 Algorithm in pseudo-code

2.2.3 Complexity

2.2.4 Area of application

2.3 Heap Sort

2.3.1 Illustration of method

2.3.2 Algorithm in pseudo-code

2.3.3 Complexity

2.3.4 Area of application

2.4 Quick Sort

2.4.1 Illustration of method

2.4.2 Algorithm in pseudo-code
2.4.3 Complexity
2.4.4 Area of application
2.5 Linear Time Sorts
2.5.1 Counting Sort
2.5.2 Radix Sort
2.6 Parallel process of sorting algorithm

Unit III: Basic Algorithmic Analysis.
3.1 Asymptotic Analysis
3.2 Definitions of asymptotic bounds.
3.3 Complexity classes:
3.3.1 Log n
3.3.2 Linear
3.3.3 Quadratic
3.4 Solving recurrence relations

Unit IV: Algorithmic Strategies
4.1 Brute force algorithms
4.1.1 Divide and conquer:
4.1.2 Maximum sub array problem
4.1.3 Strassen's algorithm for matrix multiplication
4.2 Dynamic Programming:
4.2.1 Rod cutting algorithm
4.2.2 Matrix chain multiplication
4.2.3 Greedy Algorithms
4.3 Activity selection problem
4.4 Huffman coding
4.5 Branch and Bound technique
4.5.1 Job Assignment Problem
4.5.2 0/1 Knapsack Problem

Unit V: Graph Algorithms
5.1 Graph representation
5.2 Breadth first search
5.3 Depth first search
5.4 Minimum spanning tree
5.4.1 Prims Algorithm
5.4.2 Kruskal's Algorithm
5.5 Floyd Algorithm
5.5.1 Shortest Path in a directed graph
5.6 Parallelizing graph algorithms

Laboratory Sessions:

List of Programs to be executed on computer machine using Python language

1. **Arrays (List)**
   a) Write a program to insert, delete and access element(s) in one dimensional array (List).

b) Write a program to insert, delete and access element(s) in two dimensional array (List).
c) Write Programs to implement stack and queue operations.
d) Write programs to implement non-linear List.

2. Sorting techniques:

a) Write a menu driven program to implement insertion sort
b) Write a menu driven program to implement selection sort.
c) Write a menu driven program to implement quick sort using recursion
d) Write a menu driven program to implement merge sort using recursion.
e) Achieve Parallelism on machine

3. Divide and Conquer Strategy:

a) Write a program to solve Max sub-array problem
b) Write a program to implement Strassen's algorithm to compute Matrix Multiplication
c) Achieve parallelism on machine
.

4. Dynamic and Greedy Strategy:

a) Write a program to implement Matrix chain multiplication using dynamic programming
b) Write a program to implement Activity Selection Problem using Greedy approach
c) Write a program to implement Rod Cutting Algorithm
d) Achieve parallelism on machine

5. Branch and Bound Technique:

a) Write a program to implement 0/1 Knapsack Problem
b) Write a program to implement Job assignment Problem
c) Achieve Parallelism on machine

6. Graph:

a) Write a program to implement In-order, Preorder and Post-order traversal of graph
b) Write a program to implement BFS and DFS traversal
c) Write programs to implement minimum spanning tree
d) Write a program to implement Floyd algorithm to find shortest path in a directed graph
e) Achieve parallelism on machine

Reading List

Essential Reading

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2017). *Introduction to algorithms*.
Goodrich, T. M., Tamassia, R., & Goldwasher, H, M. (2016). *Data Structures and Algorithms in Python.* Wiley.

Additional Reading

Sedgewick, R., Wayne, K. (2011). *Algorithms*, 4th Edt. Addison-Wesley.

Date: April, 2022

ALG108: Matrix Analysis and Vector Spaces

Module Code & Title: ALG108 Matrix Analysis and Vector Spaces

Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Thinley Namgyel

General objective
Important concepts in mathematics like matrices and vector spaces that can be used for storing and analyzing data will be taught in this module. The concepts learned through this module will help the students for data processing, data transformation and data evaluation. Therefore, the module will introduce matrices and their operations followed by use of matrices in various areas of Linear Algebra like solving system of linear equations, inner product spaces and eigenvalues and eigenvectors. To understand the concepts better, explanation will be done with the use of Numpy package in Python. GeoGebra software package will also be used in demonstrating the concepts taught.

Learning outcomes
On completion of the module, students will be able to:

1. Use matrices to store various information and draw meaning out of it.
2. Identify different types of matrices.
3. Apply matrix operations and use their properties in various situations.
4. Solve system of linear equations using Gaussian elimination method and Gauss-Jordan elimination method.
5. Explain the meaning of consistent system of linear equations with three variables.
6. Define vector spaces with various examples.
7. Find basis and dimension of vector spaces.
8. Find rank and nullity of a given matrix.
9. Compute different powers of the given matrix.
10. Determine orthogonal and orthonormal basis of a given matrix using Gram-Schmidt process.
11. Compute powers of matrices using orthogonal diagonalization method.
12. Compute different geometrical structures in an inner product spaces like norm of a vector and angle between vectors.
13. Perform matrix operations (addition, subtraction, multiplication, transpose, determinant, trace, power, inverse) using Numpy package in Python.
14. Solve system of linear equations using Numpy package
15. Use GeoGebra software to plot the given linear equations and check for consistency or inconsistency of the solution of system of linear equations.

Learning and Teaching Approach:

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach:

A: Assignment: 15%

The assignment will be completed during the first half of the semester. The main objective of this assignment is to verify whether students have understood the concepts taught in the class. Set of questions based on the topics covered will be provided to the students. Students will have to exhibit their understanding of the concepts through their solutions to the questions. It is an individual work and each student will have to make their submission. In order to avoid plagiarism, different sets of questions with same difficulty level will be given to the students. The assignment will be evaluated based on the following criteria and the marks achieved out of 100 will be converted to 15%.

- Correctness of the solutions: 40%
- Logical flow in the process: 20%
- Uniqueness of the solution: 20%
- Use of appropriate terms and symbols: 20%

B: Lab exam on the use of software packages: 10%

The tutor will demonstrate the use Numpy package in Python and GeoGebra software in delivering Unit I and Unit II of the subject matter. To ensure the use of software packages, a laboratory exam with weighting of 10% will be carried out towards the end of unit II. Students will be assessed on whether they can use the software packages to write simple commands and programmes to compute solutions to the given problems. Set of questions covering subject matter from Unit I and Unit II will be provided to the students where they will be required to use Python and GeoGebra software to compute the solutions. This part of the assessment will verify the achievement of learning outcome 13, 14 and 15. The lab exam will be evaluated based on the following criteria and the mark will be converted to 10%.

- Use of appropriate commands 25%
- Correctness of solutions 25%
- Analysis of solutions 50%

C: Mid-Semester Examination: 15%

Mid-semester Examination of 2.5 hours duration will be conducted in the mid of semester with at least 60% of the subject matter being covered.

D: Online Quiz: 10%

To encourage the students to use Virtual Learning Environment (VLE) and to emphasize the importance of online assessment, students will be made to take part in online quiz through VLE. The duration of the quiz will be for 1 hour and it will be conducted either during one of the classes or after class hour, depending on the availability of computer labs. The quiz will be conducted towards the end of the semester and will cover questions from all the topics included in the subject matter. Most of the questions will be MCQs or short answer questions and the marks will be reflected instantly by VLE.

E: Semester-end Examination: Portion of final marks: (50%)

Semester end Examination of 50% will be conducted for the duration of 2.5 hours. The format and pattern of the question paper will be as per the academic norm of the College. The blue print of the question paper and answer key will also be prepared along with the question paper.

Overview of Assessment Approaches and weighting

Areas of assessments	Quantity	Weighting
A. Assignment	1	15%
B. Lab exam on use of software packages	1	10%
C. Mid-Semester Examination	1	15%
D. Online Quiz	1	10%
E. Semester-end Examination	1	50%

Prerequisite: None

Subject Matter

Unit I: Introduction and Type of Matrices

(The treatment of unit I will be at an introductory level only.)

1.1 Introduction to Matrices: Use and scope of Matrices with real time examples

1.2 Type of Matrices:

- 1.2.1 Row matrix
- 1.2.2 Column matrix
- 1.2.3 Zero Matrix
- 1.2.4 Rectangular Matrix
- 1.2.5 Square Matrices
- 1.2.6 Diagonal Matrices
- 1.2.7 Scalar Matrix
- 1.2.8 Identity Matrix
- 1.2.9 Triangular matrix
- 1.2.10 Symmetric Matrices
- 1.2.11 Singular Matrix

1.3 Operations on Matrices (Only up to 3 x 3 matrices will be used for manual computations however, concepts will be extended to n x n matrices using software packages)

1.4 Equality of Matrices

1.5 Matrix Addition and associated properties

1.6 Matrix Subtraction

1.7 Scalar Multiplication

1.8 Matrix Multiplication and associated properties

1.9 Transpose of a Matrix and associated properties

1.10 Powers of a Matrix

1.11 Determinant of a square matrix

- 1.11.1 Properties of determinants (reflection property, all zero property, proportionality property, switching property, scalar multiple property, sum property, property of invariance, Triangle property)
- 1.11.2 Singular and non-singular matrices

1.12 Finding inverse of a matrix using cofactor method

Unit II: System of Linear Equations

2.1 Matrix representation of system of linear equations (homogeneous and non-homogeneous)
2.2 Substitution method for solving system of linear equation
2.3 Gaussian elimination method for solving system of linear equations
2.4 Gauss-Jordan elimination method for solving system of linear equations
2.5 Consistency (exactly one solution, infinitely many solutions) and inconsistency of system of linear equations (both algebraic and geometrical meaning)
2.6 Elementary Matrices and method for finding the inverse of a matrix.

Unit III: Vector Spaces

3.1 Definition and examples of vector spaces
3.2 Vector subspaces and examples
3.3 Linear combination, Linear Span, Linear independence
3.4 Basis and Dimension of Vector spaces
3.5 Row Space, Column Space and Null Space
3.6 Rank and Nullity of a Matrix

Unit IV: Inner Product Spaces

4.1 Definition and examples of Inner product spaces
4.2 Norm of a vector
4.3 Angle and orthogonality
4.4 Cauchy-Schwarz Inequality
4.5 Orthonormal basis: Gram-Schmidt process
4.6 QR-decomposition

Unit V: Eigen Values and Eigen Vectors

5.1 Definition and examples
5.2 Diagonalization
5.3 Computing powers of a Matrix
5.4 Orthogonal Diagonalization

Reading List

Essential Reading

Anton. H. & Rorres. C. (2005). *Elementary Linear Algebra* (9 ed.). USA: John Wiley & Sons.
Biswas, S. (2012). Textbook of Matrix Algebra (3 ed.). New Delhi: PHI Learning Pvt. Ltd.
Lang, S. (1988). *Introduction to Linear Algebra* (2 ed.). New York: Springer Verlag Inc.

Additional Reading

Cohen, A.M, Cuypers, H., & Sterk, H. (1999). *Algebra Interactive*. New Yok: Springer Verlag Inc.
Hoffman, K., & Kunze, R. (2006). *Linear Algebra* (2 ed.) New Delhi: Dorly Kindersly (India) Pvt. Ltd.
Kolman, B., & Hill, D.R. (2006). *Introduction to Linear Algebra with applications* (7 ed.) New Delhi: Dorly Kindersly (India) Pvt. Ltd.
Kreyszig, E. (2005). *Advanced Engineering Mathematics* (8 ed.) Singapore: John Whiley & Sons (Asia) Pvt. Ltd.

Date: March, 2022

DZG101: རྩོང་ཁ་བརྡ་དོན་སྦྱོང་ལེན།

Module Code & Title: DZG101 རྩོང་ཁ་བརྡ་དོན་སྦྱོང་ལེན།
Programme: University-wide Module
Credit Value: 12
Module Tutor: Tshering Penjor
Module Coordinator: Kelzang Namgyal

སྒྲིར་བཤད་ལས་དོན།

སློབ་ཚན་འདི་གི་དམིགས་ཡུལ་གསོ་བོ་ར་ སློབ་སྦྱོང་པ་ཚུ་གིས་ རང་གི་མི་ཚེ་ནང་ ལྟ་གལ་ཅོག་དང་འབྲེལ་བའི་གནད་དོན་ གཅིའི་ཐང་ལས་འབད་རྒྱུང་ རྩོང་ཁའི་ཐོག་ལུ་ བརྡ་དོན་སྦྱོང་ལེན་ ཚུལ་དང་ མཐུན་ཏོག་ཏོ་སྦེ་ འབད་ཚུགས་ནིའི་དོན་ལུ་ཨིན། དེ་མ་ཚད་ སློབ་ཚན་འདི་གིས་ རྩོང་ཁའི་ཐོག་ལུ་ ཤེས་ཡོན་འབྱི་རྒྱ་གི་ལམ་ལུགས་དང་འཁྱིལ་ཏེ་ ཨེ་ཕུགས་ནི་ལུ་ཡང་དམིགས་གཏད་བསྐྱེད་ཨིན།

སློབ་སྦྱོང་གྲུབ་འཐུས།

སློབ་ཚན་འདི་མཇུག་བསྡུས་པ་ སློབ་སྤྱི་ཚུ་གིས་
1 རྩོང་ཁའི་སྐད་ཡིག་གི་འབྱུང་རབས་དང་ རྩོང་ཁ་ཤུབ་དགོ་པའི་ཁྱངས་དང་དགོས་པ་ སྐབ་ཚུགས།
2 སྒོག་རིག་ནང་ལུ་ རྩོང་ཁའི་མཇུག་སྡེབ་ ཆུབ་ཚུགས།
3 འབྲེལ་ཐུབ་དང་ཕྱིད་ཐུབ་ ཆ་ཚན་ ཚོག་ཡིག་ ཚོག་ཤད་ཚུ་ དབྱེ་དཔྱད་འབདཝ་དེ་ མ་འངེ་ལ་བར་ ལག་ལེན་འཐབ་ཚུགས།
4 ཡུལ་ དུས་ གནས་སྐབས་དང་བསྟུན་ཏེ་ རྩོང་ཁའི་སྒོག་ལུ་ ཉན་སྐབ་འབད་ཚུགས།
5 རྩོང་ཁའི་ཐོག་ལུ་ཁིས་ཏེ་ཡོང་མེ་ཚུ་ ངག་གཤིས་དང་ མཐུན་མཚམས་སྦེ་ཤུག་ཚུགས།
6 གནས་སྐབས་དང་འཁྱིལ་བའི་དབྱེ་གཏམ་ ལག་ལེན་འཐབ་ཚུགས།
7 རྩོད་ཚོག་དང་དོན་མཚམས་ ཚུལ་མཐུན་སྦེ་ཁི་ཚུགས།
8 གཞུང་སྐེར་གྱི་ཡིག་རིགས་ཁི་ཚུགས།
9 རྩོང་ཁའི་ནང་ཡོད་པའི་འཁྲི་ཤོག་གི་རིགས་གཅིག་ཅ་ཤེས་ཐོག་ཟུང་ བཀང་ཚུགས།
10 ཡིག་རིགས་ཚུ་ ལུགས་མཐུན་དང་ལུགས་ཡངས་གཉིས་ཆ་རའི་ཐོག་ལུ་ཁི་ཚུགས།
11 ལུང་འདྲེན་དང་ཆུབ་རྟེན་གྱི་ཐོ་ འོས་འབབ་ཐུན་ཏོག་ཏོ་སྦེ་ ལག་ལེན་འཐབ་ཚུགས།

སློབ་སྟོན་ཐབས་ལམ།

དབྱེ་བ།	ཐབས་ལམ།	བདུན་ཐུག་གཅིག་ནང་ཆུ་ཚོད།	སྦྱོང་འཐུས་ཆུ་ཚོད།
དངོས་འབྲེལ།	གསལ་བཤད།	২	৬০
	སྦྱོང་ལྟ།	১	
	སྤྱན་ཁྱ།	১	
རང་སྦྱོང།	ལས་འགུལ་ཁྱེའུ།	২	৬০
	དཔེ་མཛོད། ཐུག་དེབ་ཤུག་ནི།	২	
སྦྱོང་ཚན་འདི་གི་ངོན་ཏུ་ ཡོངས་བསྡོམས་ ཆུ་ཚོད་			**১২০**

དབྱེ་ཞིབ་ཐབས་ལམ།

སྦྱོང་ཚན་འདི་གི་ངོན་ཏུ་ དུས་རྒྱུན་དབྱེ་ཞིབ་དང་སྦྱངས་རྒྱུག་དབྱེ་ཞིབ་ གཞིས་ཆ་རའི་ཐོག་ལས་ དབྱེ་ཞིབ་འབད་དགོས་ཞིན།

ཀ ལས་འགུལ་དང་བ། ཉན་ནིའི་རིག་རྩལ་དབྱེ་ཞིབ། (རྒྱུགས་ ༢༠%)

སློབ་སྟོན་པ་གིས་ འོས་འབབ་ཐུན་ཏོག་ཏོ་ (ཐུ་བརྒྱང་ཡོང་མེ་ཅིག) གཙམ་ཁ་ཆུབ་སྟེ་ རང་ཆུང་གི་ཐོག་ལས་

ཁྱེ་སེམ་སིམ་སྒེ་ཤ་ནས་བསྒྲག ངོ་རྩང་ ཚར་ཅིག་ཤ་ནས་ཅིག་ངང་གཅིག་ཁར་ཟེན་བྱིས་བཏབ་བསྒྲག་ཞིནམ་ལས་ ཤ་ནས་མི་འདི་ ཚོག་ཐབ་འབབ་དེ་ བྱི་བསྒྲག དེ་གི་དམིགས་ཡུལ་གཙོ་བོ་ ཤ་ནས་ཏེ་ཏ་ཐོ་ནང་ ཤ་ནས་ཏེ་བྱི་རྒྱགས་མེ་རྒྱགས་དབྱེ་ཞིབ་ འབང་རིའི་དོན་ལུ་ཨིན།

སྐྱག་ཀྱི་ཚད་གཞི།

- གོ་དོན་ལེན་ཏེ་ རང་ཚོག་ནང་བཤད་པ་རྐྱབ་ཐུབ་ཨིན། ༧༠%
- ཐེབ་སྒོར། ༡༠%
  - ཤ་ནས་བྱི་རིའི་རིགས་རྒལ་ཡར་རྐྱངས་ཀྱི་ཐོག་ལཆར། ༣%
  - རང་གི་ཤ་ནས་རིའི་རིགས་རྒལ་ཡར་རྐྱངས་ཀྱི་ཐོག་ལཆར། ༣%

དབུ་གསོ། དབྱེ་དཔྱད་སྐན་ཤུ་དང་ གྲོས་འཆར་ བསྡོམས་ཏེ་ ཨོག་ལེབ་གཅིག་ཐེ་དགོ།

༡ ལས་འགྱུལ་གཞིས་པ། སྐབ་ནིའི་རིགས་རྒལ་དབྱེ་ཞིབ། (སྐྱག་ ༢༠%)

སྐོབ་སྐོན་པ་གིས་ སྤྱིར་བཏང་མི་སྡེའི་ནང་ ཇོང་ཁ་བརྡ་དོན་སྐོང་ལེན་ནང་ལུ་ དཀའ་ངལ་གི་ཅ་ར་འཛུང་དོ་ཡོད་ཨིན་ན་གདམ་ཁ་རྐྱབ་ཞིནམ་ལས་ འཛུས་མི་ ༤ ར་འབད་མིའི་སྡེ་ཚན་ནང་སྐྱེ་ སྐོབ་ཁང་ནང་ལུ་ སྐར་མ་ ༧༤ འི་རིང་ལུ་ སྤྱན་ཞུའབད་བསྒྲག་དགོ། འཛུས་མི་རེ་གིས་ སྐར་མ་ ༣ ར་གསལ་བཤད་འབད་དགོ། དེ་གི་དམིགས་ཡུལ་གཙོ་བོ་སྐབ་ནིའི་རིགས་རྒལ་རྐྱབ་ཀྱི་ དབྱེ་ཞིབ་འབད་ནིའི་དོན་ལུ་ཨིན།

སྐྱག་ཀྱི་ཚད་གཞི།

- དོན་ཚན་དང་འབྲེལ་བ། ༡༠%
- སྐད་ཡིག་སྤྱིར་བ། ༣%
- གསལ་བཤད་འབད་ཐངས
  - ཐོག་ཆགས་མེད་པ། ༣%
  - རྩོད་རྙོག་དག་པ། ༣%
  - སྐད་ཀྱི་སིང་ཐབ། ༢%
  - གཟུགས་ཀྱི་རྣམ་འགྱུར། ༧%
  - ཚོར་སྣོངས། ༢%
- ཤན་མི་ཚུ་འབྲེལ་གཏོང་འབད་ཐངས། ༢%

༢ ལས་འགྱུལ་གསུམ་པ། སྡུག་ནི་དང་བྱི་ནིའི་རིགས་རྒལ་དབྱེ་ཞིབ། (སྐྱག་ ༡༠%)

ཚོག་འབྲུ་ ༧༡༠༠-༢༠༠༠ གི་བར་ན་ ཡོང་ཁའི་རྩོམ་བྱིས་ཚེག་ སྐོབ་དཔོན་དང་སྐོབ་སྡུག་མཉམ་རུབ་ཀྱི་ ཐོག་ལས་ གདམ་ཁ་ཆུབ་ཞིནམ་ལས་ རང་ཆུང་གི་ ཐོག་ལས་ དབྱེ་དཔྱད་སྐན་ཤུ་ ཁྱེ་གི་དམིགས་གཏད་འདི་ སྐོབ་སྡུག་ཚུ་གིས་ སྡུག་གིས་ དེ་གི་ཐོག་ལ་ ཤ་ནས་ཏེ་ཏ་ཐོ་ནང་ དབྱེ་དཔྱད་འབད་ཐངས་ཀྱི་རིག་ སྡུལ་ཐོག་ ཡིག་ཐོག་ལུ་ བགོད་ཚུགས་ནིའི་དོན་ལུ་དང་ ལུང་འདེན་དང་ཆུབ་ཤེན་ལག་ལེན་འཐབ་ཐངས་ཚུ་ དབྱེ་ཞིབ་འབད་ནིའི་ཨིན། སྐོབ་སྡུག་ར་གིས་ རྩོམ་ཡིས་ཀྱི་བསྒྲུབ་དོན་ར་དང་ དབྱེ་དཔྱད་སྐན་ཤུ་ཡི་དགོས་ཨིན། དབྱེ་དཔྱད་སྐན་ཤུ་ འདི་ ཚོག་འབྲུ་ ༢༠༠༠ ཀྱི་ནང་འགོངས་ཡི་དགོས་ཨིན།

སྐྱག་ཀྱི་ཚད་གཞི།

- རྩོམ་ཡིས་ཀྱི་བསྒྲུབ་དོན་གཙོ་བོ་ཚུ་ མ་འཛོལ་བར་ བགོད་ཐངས། ༤%
- དཔྱད་པ་གི་ཐོག་ལས་ དབྱེ་དཔྱད་འབད་ཐངས། ༥%
- གནད་དོན་ཚུ་གི་རིམ་སྒྲིག་ཐངས། ༣%
- འོས་འབབ་དང་འཛིལ་བ་ཡོད་པའི་ཚིང་ཚིག་ལག་ལེན་འཐབ་ཐངས། ༣%
- ལུགས་མཐུན་དང་འཁྱིལ་ཏེ་འབྱི་ཐངས། ༡%
- སྐེབ་སྒོར་དག་པ། ༢%
- ཚིག་སྒོར་ཚུལ་མཐུན་ལག་ལེན་འཐབ་ཐངས། ༢%
- ལུང་འདེན་དང་རྒྱབ་རྟེན་ལག་ལེན་འཐབ་ཐངས། ༣%
- འབྱི་བགོད། ༢%

८ སློབ་དུས་ཚོས་རྒྱུགས། (སྐུགས་ ३०%)

ལས་རིམ་འདི་ནང་བཅའ་མར་གཏོགས་མི་ཚུ་གིས་ སློབ་དུས་མཇུག་བསྡུམས་ད་ དུས་ཡུན་ཚུ་ཚོང་ २ ་རིང་ལུ་ སྐུགས་ ३० འི་འབྱི་རྒྱུགས་ཕྱལ་དགོ་པ་ཨིན།

དྲན་གསོ། འབྱི་རྒྱུགས་ཀྱི་སྐུགས་དང་དུས་ཡུན་ཚུ་ཚོང་ སངས་སོའི་མཚོ་རིམ་སློབ་གྲྭའི་ལས་ལུགས་དང་འཁྱལ་ཏེ་ལེན་ཞིནམ་ལས་ སྐུགས་བརྒྱ་ཚ་ ३० ནང་ལུ་ པས་དགོ་པ་ཨིན།

དབྱེ་ཞིབ་ཐབས་ལམ་དང་སྤྱིད་ཚད་ཀྱི་བཀོད་རིས།

ཐབས་ལམ།	དབྱེ་ཞིབ་ཀྱི་དབྱེ་བ།	གྲངས་ཀ།	སྐུགས་ཀྱི་བརྒྱ་ཚ།
དུས་རྒྱུན་དབྱེ་ཞིབ།	ཀ། ཁནས་ནེའི་རིས་རིགས་རྩལ་དབྱེ་ཞིབ།	།	३०%
	ཁ། སྐབས་ནེའི་རིས་རིགས་རྩལ་དབྱེ་ཞིབ།	།	३०%
	ག། ལྷག་ནི་ཐུ་ནེའི་རིས་རིགས་རྩལ་དབྱེ་ཞིབ།	།	३०%
སློབ་དུས་ཚོས་རྒྱུགས།	ང་ འབྱི་རྒྱུགས།	།	३०%
	སྐུགས་བསྡོམས་ **१०० **		

སྤྱོད་ཚུལ། མེད།

ནང་དོན།

ལས་ཚན་དང་པ། སྐད་ཡིག་གི་ངོ་སྤྲོད།
- ।.। རྩོང་ཁའི་སྐད་ཡིག་གི་འགྱུང་རབས།
- ।.२ ཐུམ་བཏང་ རྩོང་ཁ་ལྟབ་དགོ་པའི་དགོས་པ།
- ।.३ དམེགས་བསལ་ མཚོ་རིམ་སློབ་གྲྭ་ནང་ལུ་ རྩོང་ཁའི་སྤྱོང་ཚན་འདི་ ལྟབ་དགོ་པའི་དགོས་པ།

ལས་ཚན་གཉིས་པ། བརྡ་དོན་འཛུལ་རིག
- २.। སྤྲོག་རིག་ནང་ རྩོང་ཁ་བཏུགས་ཐངས།
- २.२ སྤྲོག་རིག་ནང་ལུ་ རྩོང་ཁ་འབྱི་ཐངས།

ལས་ཚན་གསུམ་པ། ཡི་གུའི་སྤྱོར་བ།
- ३.। ཚོག་གོགས།
- ३.२ འབྲེལ་ཚོག་ལས་ལེན་འཐབ་ཐངས།
- ३.३ འབྲེལ་སྐྱ་
- ३.४ ཕྲེད་བཅས།
- ३.५ ཕྲག་བཅས།
- ३.७ ཚག་ཤད་ལས་ལེན་འཐབ་ཐངས།

ལས་ཚན་བཞི་པ། རྩོང་ཁའི་ངག་གཤིས་དང་འཁྱལ་ཏེ་སྐབས་ཐངས།
- ४.। ཁ་བཟང་།
- ४.२ ཡལ་སྐད་ཞེ་ས།
- ४.३ མིང་ཚོག་དང་བྱ་ཚིག་ཁྱད་ཚོག་ཚུ་འོས་འབབ་ལྡན་མ་སྦེ་ལས་ལེན་འཐབ་ཐངས།
- ४.४ དབྱེ་གཏམ།
- ४.५ རྩོང་ཁ་ཉན་ཆུང་གི་མིང་ཚོག་ལས་ལེན་འཐབ་ཐངས།

ལས་ཚན་ལྔ་པ། རྩོང་ཁའི་ངག་གཤིས་དང་འཁྱལ་ཏེ་སྐབས་ཐངས།
- ५.। ཚོག་མཚམས་བཅད་དེ་ སྐབས་ཐངས།
- ५.२ མགོ་འངོས་དབྱངས་གསུམ་ཞུགས་པའི་རྩོང་སྐྱ།
- ५.३ རྗེས་འཇུག་གི་སྐྱ་ཉེ་ལ་ཏུ་བཏོན་དང་མ་དགོ་པའི་ཡིད་རྟོགས་ཚུ་ ཁྱད་པར་ཅུ་སྟེ་ སྐབས་ཐངས།
- ५.४ རྗེས་འཇུག་མེད་རྩང་ཡོངས་བཟུམ་སྐབས་ཐངས།
- ५.५ མིང་མཚའ་མེད་རྩང་ཡོངས་བཟུམ་སྐབས་ཐངས།

ལས་ཚན་དྲུག་པ། བྱི་ནེའི་རིག་རྩལ།
- ६.। རྩོང་ཚོག་འབྱི་ཐངས།
- ६.२ དོན་མཚམས་འབྱི་ཐངས།
- ६.३ སྐན་ཁུ་འབྱི་ཐངས།
- ६.४ འབྱི་ཐོག་གི་རིགས་བགང་ཐངས།
- ६.५ གོས་ཚོང་འབྱི་ཐངས།

ལས་ཚན་བདུན་པ། ཡིག་འགྲུལ།
- ७.। ཡིག་ཁུང་འབྱི་ཐངས།
- ७.२ མགོན་ཁུ་འབྱི་ཐངས།
- ७.३ གཏང་ཡིག་འབྱི་ཐངས།
- ७.४ ཁུ་ཡིག་དང་ཁུ་ཚོག་/བཤེར་ཡིག་ འབྱི་ཐངས།
- ७.५ གཅ་ཡིག་འབྱི་ཐངས།
- ७.७ ཁྱབ་བསྒྲགས་ཀྱི་རིགས་འབྱི་ཐངས།

ལས་ཚན་བརྒྱད་པ། ཤེས་ཡོན་འབྱི་རྩལ།

Year 2: Semester I

DST203: Probability Distributions I

Module Code &Title: DST203 Probability Distributions I
Programme: BSc in Statistics
Credit: 12
Module Tutor: Dr. Bishal Gurung

General Objective

The objective of the module is to introduce the basic concepts of various statistical distributions of random variables using Spreadsheet. This module will help the students understand fitting the various distribution depending on the characteristics of the datasets under consideration. It would also help them in understanding the concepts involved in parameter estimation and testing the goodness of fit of the fitted distribution.

Learning Outcomes

On completion of the module, students will be able to:

1. Explain the basic concepts of probability distribution.
2. Fit the various discrete probability distributions.
3. Find the moments of the discrete distributions by various methods.
4. Estimate the parameters of the continuous probability distributions.
5. Find the various characteristics features of the datasets using expectations as well as moment generating function (mgf) methodology for all the continuous distributions.
6. Evaluate the logic behind the exact sampling distributions.
7. Apply Jacobian transformation in distributions of variables.

8. Explain bivariate normal distribution and derive its marginal and conditional distribution.
9. Apply the different distributions for modelling the real datasets.
10. Apply various distributions to test significance.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory session	1	
Independent study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment (10%)**

An individual assignment will be given during the first half of the semester. The assignment will comprise of problem solving based on the subject matters Unit I and Unit II to assess the students' ability in fitting various discrete and continuous probability distribution. The assignment will be assessed using marking criteria.

- Correctness of the solutions: 40%
- Logical flow in the process: 20%
- Uniqueness of the solution: 20%
- Use of appropriate terms and symbols: 20%

Then the final score will be converted out of 10%.

B. **Laboratory Assignment (15%)**

Laboratory assignment will be carried out as follows:

- **Laboratory report- 5%**
  Students will submit a weekly record of the laboratory session of 250-500 words to keep track of his/her progress which will be assessed for 5 marks. At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Each student will have to submit minimum of 10 laboratory reports in a semester. Template for laboratory report is given in Appendix A of the DPD.

  Laboratory report will be assessed using marking criteria:

- Objective: 1
- Methods: 2
- Results: 1
- Conclusion: 1

- **Laboratory Exam- 10%**
  A laboratory exam for the duration of 1 hour will be conducted towards the end of a semester after the last day of regular teaching. . Lab exam will be assessed using the following criteria:

- Correctness of the solutions: 40%
- Use of appropriate Spreadsheet functions/formulae/graphs 30%
- Inference on findings 30%

The final score of each student will be converted out of 10%.

C. **Mid-Semester Examination (15%)**
Mid-semester examination will be conducted in the mid of semester with at least 60% of the subject matters being covered for the duration of 3 hours. The exam will be conducted out of 60 marks and the scores of each student will be converted to 15%.

D. **Semester-end Examination (60%)**
Semester-end Examination will be conducted for 3 hours with all the subject matters being covered in a semester. The exam will be conducted out of 60 marks and the student will be awarded directly of what he/she scores during examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Laboratory Assignment	Laboratory Report	10	5%
	Laboratory Exam	1	10%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	60%

Prerequisite: None

Subject Matter
Unit I: DISCRETE PROBABILITY DISTRIBUTIONS
1.1 Uniform distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.2 Bernoulli distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.3 Binomial distribution:PMF, CDF, expectation, variance, mgf, characteristic functions
1.4 Poisson distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.5 Negative – Binomial distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.6 Geometric distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.7 Hypergeometric distribution: PMF, CDF, expectation, variance, mgf, characteristic functions
1.8 Multinomial distribution: PMF, CDF, expectation, variance, mgf, characteristic functions

Unit II: CONTINUOUS PROBABILITY DISTRIBUTIONS AND PROPERTIES
2.1 Rectangular distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.2 Exponential distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.3 Cauchy distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.4 Normal distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.5 Gamma distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.6 Beta distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.7 Weibull distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.8 Lognormal distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.9 Logistic distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.10 Pareto distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
2.11 Bivariate normal distribution-conditional and marginal

Unit III: EXACT SAMPLING DISTRIBUTIONS

3.1 Central *t* distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
3.2 χ^2 distribution: PDF, CDF, expectation, variance, mgf, characteristic functions
3.3 F distribution: PDF, CDF, expectation, variance, mgf, characteristic functions

List of Laboratory sessions

1. Discrete probability distributions
    a. Calculate the general probability
    b. Creating simple probability distribution
    c. Fitting the distribution
    d. Generate a random sample for the distribution with parameter size and probability
    e. Calculate the expectation and variance
2. Continuous probability distributions
    a. Calculate the general probability
    b. Creating probability distribution
    c. Fitting the distribution
    d. Generate a random sample for the distribution with parameter size and probability
    e. Calculate the expectation and variance
3. Exact sampling distributions
    a. Calculate the general probability
    b. Creating probability distribution
    c. Fitting the distribution
    d. Generate a random sample for the distribution with parameter size and probability
    e. Calculate the expectation and variance

Laboratory sessions will be performed in python using Numpy, SciPy and Statistic.py libraries

Reading Lists
Essential Reading

Goon, A. M., Gupta, M. K., and Dasgupta, R. (2008). *Fundamentals of Statistics,* Vol. I. Atlantic Publishers, Calcutta.

Hogg, R. V., and Craig, A. T. (2012). *Introduction to Mathematical Statistics,* Prentice-Hall, New Delhi.

Mood, A. M., Graybill, F. A., and Boes, D. C. (2011). *Introduction to Theory of Statistics,* Cambridge University Press, New Delhi.

Rohtagi, V. K., and Ehsan, M. (2015). *Introduction to Probability Theory and Mathematical Statistics*, John Wiley, New Delhi.

Additional Reading

Goon, A. M., Gupta, M. K., and Dasgupta, R. (1986). *Outline of Statistics,* Vol. I. World Press, Calcutta.

Hoel, P. G. (1971). *Introduction to Mathematical Statistics,* John Wiley, New Delhi.

Date: March, 2022

PLT203: R Programming for Data Analysis

Module Code & Title: PLT203 Programming for Data Analysis
Programme: BSc in Statistics

Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
The module will enable students to use R for data analysis. The students will be introduced to R programming language and learn the basic syntax, semantics, grammars, and vocabulary of R programming language to aid in data analysis. Further, they will learn how to expand R by importing and configuring software packages necessary for statistical analysis and data visualization.

Learning Outcomes
On completion of the module, students will be able to:
1. Use R syntax and semantics in writing programs in R.
2. Apply the concepts of objects and assignment.
3. Demonstrate the concepts of vector and data types.
4. Load a Workspace containing an R data frame, edit the dataset, and save the Workspace.
5. Access online resources for R and import new function packages into the R Workspace.
6. Import, review, manipulate and summarize data-sets in R.
7. Explore data-sets to create testable hypotheses and identify appropriate statistical tests.
8. Perform appropriate statistical tests using R.
9. Create and edit visualizations with R.

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**75**
	Laboratory session	2	
Independent Study	Self-study	3	**45**
Total			**120**

Assessment Approach

A. Laboratory Assessment: (35%)
Laboratory Assessment will be assessed based on the following components:
- Laboratory Assignments: 15%.
- Laboratory Examination: 10%
- Viva Voce: 10% (Laboratory assignments: 7%, Laboratory examination: 3%).

Laboratory Assignments (a total of 10 with one assignment for first three units and one each for remaining units) will be based on the concepts taught in the theory class. Students will be provided a set of programming questions every week covering the concepts taught on each unit. The students will have to submit the solutions at the end of the Laboratory session through the VLE.

The following rubrics will be used to assess the set of programming questions. Each set will be assessed out of 100 marks and converted to 1.5%.

Program (100)	**(Excellent) 100-81%**	**(Good) 80-61%**	**(Satisfactory) (60-41% of the points)**	**(Unsatisfactory) (<=40% of the points)**
Requirements and Delivery	• Completed between 90-	• Completed between 80-90%	• Completed between 70-	• Completed less than 70% of

(50 points)	100% of the requirements. • Delivered on time, and in correct format.	of the requirements. • Delivered on time, and in correct format.	80% of the requirements. • Delivered on time, and in correct format.	the requirements. • Delivered on time but not in correct format.
Program execution (20 points)	• Executes without errors excellent user prompts, good use of symbols, spacing in output. • Thorough and organized testing or input validation has been completed.	• Executes without errors. • User prompts are understandable, minimum use of symbols or spacing in output. • Most testing or input validation completed.	• Executes without errors. • User prompts contain little information, poor design. • Some testing or input validation has been completed.	• Does not execute due to errors. • User prompts are misleading or non-existent. • No testing has been completed, or no input validation.
Design of logic (10 points)	• Program is logically well designed.	• Program has slight logic errors that do no significantly affect the results	• Program has significant logic errors.	• Program is incorrect.
Coding Standards (10 points)	• Includes name, date, and assignment title. • Excellent use of white space. • Creatively organized work. • Excellent use of variables (no global variables, unambiguous naming).	• Includes name, date, and assignment title. • Good use of white space. • Organized work. • Good use of variables (no global variables, unambiguous naming)	• Includes name, date, and assignment title. White space makes program fairly easy to read. • Organized work. • Good use of variables (few global variables, unambiguous naming).	• No name, date, or assignment title included. • Poor use of white space (indentation, blank lines). • Disorganized and messy. • Poor use of variables (many global variables, ambiguous naming).
Documentation (10 points)	• Clearly and effectively documented including descriptions of all class variables. • Specific purpose noted for each function, control structure, input requirements,	• Clearly documented including descriptions of all class variables. • Specific purpose is noted for each function and control structure.	• Basic documentation has been completed including descriptions of all class variables. • Purpose is noted for each function.	• Very limited or no documentation included. • Documentation does not help the reader understand the code.

	and output results.			

Laboratory examination for a duration of three hours will be conducted after the completion of the module and before semester-end examination and will cover all the units. Each student will be given two questions and will be graded out of 100 based on the rubric mentioned above. The marks obtained will then be converted out of 10%.

Viva voce for the laboratory assignments will be conducted at least two times to assess the students' understanding of the lab assignments. Viva voce will also be conducted for the laboratory examination. The following rubrics will be used for viva voce. Each viva voce will be of 15-20 minutes and will be assessed out of 100 marks and converted to 7% for laboratory assignments and 3% for lab examination respectively.

Program (100)	**(Excellent) 85-100%**	**(Good) 61-84%**	**(Satisfactory) (<=60% of the points)**
Knowledge in programming (50 points)	Demonstrates deep knowledge, answer the questions with explanation and elaboration.	Adequate knowledge of most topics, answer the questions but fails to elaborate.	Superficial knowledge of topic, only able to answer basic questions.
Problem-solving ability (30 points)	Efficient mapping of theory concepts with practical problem-solving approaches.	Moderate mapping of theory concepts with practical problem-solving approaches.	Improper mapping of theory concepts with practical problem-solving approaches.
Critical Thinking (20 points)	Can predict and defend problem outcomes.	Approximately predicts and defends problem outcomes.	Is unable to predict problem outcomes for the given input data set.

B. Mid-Semester Examination: (15%)

Mid-semester examination will be conducted in the mid of the semester with at least 60% of the subject matters being covered for the duration of 2 hours with maximum marks of 40. The final marks will be converted out of 15.

C. Semester-end Examination: (50%)

Semester end Examination for the duration of two and a half hours will be conducted with maximum marks of 50 and final marks will be taken without conversion.

Overview of Assessment Approaches

Areas of Assignments		**Quantity**	**Weighting**
A. Laboratory Assessment	Weekly lab assignments	10	15%
	Laboratory examination	1	10%

	Viva-voce	3	10%
B. Mid-Semester Examination		1	15%
C. Semester-end Examination		1	50%
Total			100%

Prerequisite: PLT102 Programming in Python

Subject Matter

Unit I: Preliminaries

1.1 The R environment
1.2 R and statistics
1.3 Using R interactively
1.4 Getting help with functions and features
1.5 R commands, case sensitivity, etc.
1.6 Recall and correction of previous commands
1.7 Executing commands from or diverting output to a file
1.8 Data permanency and removing objects

Unit II: Simple manipulations: numbers and vectors

2.1 Vectors and assignment
2.2 Vector arithmetic
2.3 Generating regular sequences
2.4 Logical vectors
2.5 Missing values
2.6 Character vectors
2.7 Index vectors; selecting and modifying subsets of a data set
2.8 Other types of objects:
2.8.1 Ordinal factors
2.8.2 Nominal factors

Unit III: Objects, their modes and attributes

3.1 Intrinsic attributes: mode and length
3.2 Changing the length of an object
3.3 Getting and setting attributes
3.4 The class of an object
3.5 Ordered and unordered factors

Unit IV: Arrays and matrices

4.1 Arrays
4.2 Array indexing. Subsections of an array
4.3 Index matrices
4.4 The array () function
4.5 Mixed vector and array arithmetic.
4.6 Recycling rule
4.7 The outer product of two arrays
4.8 Generalized transpose of an array
4.9 Matrix facilities:
4.9.1 Matrix multiplication
4.9.2 Linear equations and inversion
4.9.3 Eigenvalues and eigenvectors

4.9.4 Singular value decomposition and determinants
4.9.5 Least squares fitting and the QR decomposition)
4.10 Forming partitioned matrices, cbind() and rbind()
4.11 The concatenation function, c(), with arrays
4.12 Frequency tables from factors and grouped data

Unit V: Lists and data frames

5.1 Lists:
5.1.1 Constructing and modifying lists
5.1.2 Concatenating lists
5.2 Data frames:
5.2.1 Making data frames
5.2.2 attach() and detach()
5.2.3 Working with data frames
5.2.4 Attaching arbitrary lists
5.2.5 Managing the search path
5.3 Data cleaning
5.3.1 Renaming column names
5.3.2 Formatting the output
5.3.3 Reshape
5.3.4 Remove empty columns and rows
5.3.5 Remove duplicate records
5.3.6 Imputation method for missing values
5.3.7 Identifying outliers

Unit VI: Reading data from files

6.1 The read.table() function
6.2 The scan() function
6.3 Accessing built in datasets
6.4 Loading data from other R packages
6.5 Editing data

Unit VII: Grouping, loops and conditional execution

7.1 Grouped expressions
7.2 Control statements
7.3 Conditional execution: if statements
7.4 Repetitive execution: for loops, repeat and while

Unit VIII: Writing your own functions

8.1 Simple examples
8.2 Defining new binary operators
8.3 Named arguments and defaults
8.4 Assignments within functions
8.5 More advanced examples:
8.5.1 Efficiency factors in block designs
8.5.2 Dropping all names in a printed array
8.5.3 Recursive numerical integration
8.6 Scope

8.7 Customizing the environment
8.8 Classes, generic functions and object orientation
8.9 Reusable functions:
8.9.1 Calling function

Unit IX: Graphical Procedures

9.1 High-level plotting commands:
9.1.1 The plot() function
9.1.2 Displaying multivariate data
9.1.3 Display graphics
9.1.4 Arguments to high-level plotting functions
9.2 Low-level plotting commands:
9.2.1 Mathematical annotation
9.2.2 Hershey vector fonts
9.3 Interacting with graphics
9.4 Using graphics parameters:
9.4.1 Permanent changes:
9.4.1.1 The par() function
9.4.2 Temporary changes:
9.4.2.1 Arguments to graphics functions
9.5 Graphics parameters list:
9.5.1 Graphical elements
9.5.2 Axes and tick marks
9.5.3 Figure margins
9.5.4 Multiple figure environment
9.6 Device drivers:
9.6.1 PostScript diagrams for typeset documents
9.6.2 Multiple graphics devices
9.7 Dynamic graphics

List of Laboratory Sessions

1. Use the R Commander to input data, then using read.table() directly to achieve the same result
1.1 Determine number rows, columns, missing values of data
1.2 Check the type of data
1.3 Print the name of variables
2 Use the functions mean() and range() to find the mean and range of:
2.1 the numbers 1, 2, . . ., 21
2.2 the sample of 50 random normal values, that can be generated from a normaL distribution with mean 0 and variance 1 using the assignment y <- rnorm(50).
2.3 the columns height and weight in the data frame women. [The datasets package that has this data frame is by default attached when R is started.]
2.4 Repeat (2.2) several times, on each occasion generating a new set of 50 random numbers.
3 Extract the following subsets from the data frame ais: (a) Extract the data for the rowers. (b) Extract the data for the rowers, the netballers and the tennis players. (c) Extract the data for the female basketabllers and rowers.
4 Create a function that will return the sum of 2 integers.
5 Create a function what will return TRUE if a given integer is inside a vector.

6 Create a function that given a data frame will print by screen the name of the column and the class of data it contains (e.g. Variable1 is Numeric).

7 Create the function unique, which given a vector will return a new vector with the elements of the first vector with duplicated elements removed.

8 Create a function that given a vector will print by screen the mean and the standard deviation, it will optionally also print the median.

9 Check the class of each of the columns of the data frame cabbages (MASS). Do side by side plots of HeadWt against Date, for each of the levels of Cult.

Reading List

Essential Reading

Crawley, M.J. (2012). *The R book*. John Whiley & Sons.

Matloff, N. (2011). *The Art of R programming: A tour of statistical software design*. No Starch Press.

Additional Reading

Braun, W. J., Murdoch, D. J. (2017). *A First Course in Statistical Programming with R*. Cambridge University Press. New York.

Gardener, M. (2012). *Beginning R: The Statistical Programming Language.* Wiley Publications.

Date: March, 2022

AMT209 Mathematical Logic

Module Code & Title: AMT209 Mathematical Logic
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Thinley Namgyel

General objective

The module is designed to equip the students with fundamental concepts in Discrete Mathematics such as logic, proofs, division algorithm, lattices and recurrence relations. The concepts and techniques taught in this module will help the students to relate everyday languages to propositional logic and prove mathematical statements using various methods of proofs.

Learning outcomes

On completion of the module, students will be able to:

1. Translate English statements into logical statements and vice versa.
2. Test the validity of the arguments.
3. Apply various methods to prove theorems and problems.
4. Write prime factorization of a given number.
5. Use the concept of modular arithmetic to study its application in encryption.
6. Identify conjectures related to prime numbers.
7. Verify if a given set is a partially ordered set (POSET) or not.
8. Determine if a POSET is a lattice along with the Hasse diagram.
9. Examine the isomorphism between POSETs and lattices.
10. Solve recurrence relations with usual methods and by the method of generating functions.

Teaching and Learning Approach:

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach:

A: Assignment: 10%

The assignment will be completed during the first half of the semester. The main objective of this assignment is to verify whether students have understood the concepts taught in the class. Set of questions based on the topics covered will be provided to the students. Students will have to exhibit their understanding of the concepts through their solutions to the questions. It is an individual work and each student will have to make their submission. In order to avoid plagiarism, different sets of questions with same difficulty level will be given to the students. The assignment will be evaluated based on the following criteria and the final mark will be converted to 10%.

Correctness of the solutions:	40%
Logical flow in the process:	20%
Uniqueness of the solution:	20%
Use of appropriate terms and symbols:	20%

B: Mid-Semester Examination: 15%

Mid-semester Examination of 3 hours duration will be conducted in the mid of the semester with at least 60% of the subject matter being covered. The mid-semester exam will be conducted out of 60 marks and will be converted to 15%. The question paper for mid-semester examination will be prepared in accordance with the format for semester-end question paper so that the students get to preview the format and pattern for semester-end examination. The tutor will evaluate the answer scripts based on the prepared answer key.

C: Class Test: 10%

The objective of the class test is to check how students can demonstrate their understanding of the concepts in a limited time. A class test of 1 hour duration covering subject matter from unit IV and unit V will be conducted during one of the tutorial classes. It will be evaluated based on the answer key prepared as per the questions for the test.

D: Online Quiz: 5%

To encourage the students to use Virtual Learning Environment (VLE) and to emphasize the importance of online assessment, students will be made to take part in online quiz through VLE. The duration of the quiz will be for 1 hour and it will be conducted either during one of the classes or after class hour, depending on the availability of computer labs. The quiz will be conducted towards the end of the semester and will cover questions from all the topics included in the subject matter. Most of the questions will be MCQs or short answer questions and the marks will be reflected instantly by VLE.

E: Semester-end Examination: 60%

Semester end Examination will be conducted for the duration of 3 hours and it will cover subject matter from all the units. The exam will be conducted out of 60 marks. The format and pattern of

the question paper will be as per the academic norm of the College. The blue print of the question paper and answer key will also be prepared along with the question paper.

Overview of Assessment Approaches

Areas of assessments	Quantity	Weighting
A. Assignment	1	10%
B. Mid-Semester Examination	1	15%
C. Class Test	1	10%
D. Online Quiz	1	5%
E. Semester-end Examination	1	60%

Prerequisite: None

Subject matter

Unit I: Foundations of Logic and Proofs

1.1 Propositional Logic
- 1.1.1 Introduction
- 1.1.2 Propositions
- 1.1.3 Conditional statements-inverse
- 1.1.4 Converse and contrapositive statement
- 1.1.5 Biconditional statements
- 1.1.6 Compound statements and truth tables
- 1.1.7 Translating English sentences into expressions involving propositional variables and logical connectives

1.2 Propositional Equivalences
- 1.2.1 Introduction
- 1.2.2 Tautology
- 1.2.3 Contradiction and contingency
- 1.2.4 Logical equivalences
- 1.2.5 De Morgan’s laws)

1.3 Predicates and Quantifiers
- 1.3.1 Introduction
- 1.3.2 Predicates
- 1.3.3 Quantifiers-existential quantifiers and uniqueness quantifiers
- 1.3.4 Logical equivalences involving quantifiers

1.4 Rules of Inference
- 1.4.1 Introduction
- 1.4.2 Valid arguments in Propositional Logic
- 1.4.3 Rules of inference for Propositional Logic
- 1.4.4 Combining rules of inference for propositions and quantified statements

Unit II: Method of Proof

2.1 Introduction

2.2 Direct proof, indirect proof
2.3 Proof by contradiction
2.4 Counter examples
2.5 Well-ordering property
2.6 Mathematical induction.

Unit III: The Integer and Division

3.1 Introduction
3.2 Division Algorithm
3.3 Modular Arithmetic
3.4 Fundamental Theorem of Arithmetic
3.5 Primes
- 3.5.1 Prime factorization
- 3.5.2 The infinitude of primes
- 3.5.3 The distribution of primes
- 3.5.4 The Prime Number Theorem
- 3.5.5 Goldbach's conjecture
- 3.5.6 The Twin Prime conjecture

Unit IV: Partially Ordered Sets and Lattices

4.1 Definition and examples of Partially Ordered Sets and Hasse Diagrams
4.2 Maximal and Minimal elements, Greatest and Least Elements
4.3 Least Upper Bound (LUB) and Greatest Lower Bound (GLB)
4.4 Lattices& Isomorphic lattices
4.5 Properties of lattices and their proofs
4.6 Bounded and Complemented Lattices
4.7 Distributive lattices & Sub-lattices

Unit V: Recurrence Relations

5.1 Introduction of Recurrence relations
5.2 Linear recurrence relation with constant coefficients
5.3 Homogeneous solutions (distinct roots, repeated roots, and mixture of both distinct and repeated roots)
5.4 Particular solutions
5.5 Total solutions
5.6 Solution by the method of generation functions

Reading List

Essential Reading

Johnsonbaugh, R. (2009). *Discrete Mathematics* (7thed.). New York**:** Pearson Education Inc.
Liu, C.L. (2000). *Elements of Discrete Mathematics* (2nded.). New Delhi: McGraw-Hill.
Rosen, K.H. (2007). *Discrete Mathematics and its Applications* (6thed.). New Delhi: Tata McGraw Hill.
Tremblay, J.P., & Manohar, R. (2007). *Discrete Mathematical Structures with Applications to Computer Science*. New Delhi: Tata McGraw Hill.

Additional Reading

Fletcher, N.R. (1985). *Discrete Structures: an introduction to mathematics for computer science*. New Jersey: Prentice-Hall Inc.

Kolman, B., Busby, R, C., & Ross, S. (1996). *Discrete Mathematical Structures*. (3rd ed.). New Jersey: Prentice-Hall Inc.
Lipschutz, S., & Lipson., M (2001). *2000 Solved Problems in Discrete Mathematics. (*2nd ed). New Delhi: TMH.

Date: March, 2022

CAE201 Database Systems

Module Code and Title: CAE201 Database Systems
Programme: BSc in Statistics
Credit Value: 12
Module Tutors: J.Gurubalan

General Objectives:

This module presents a comprehensive introduction to relational database management systems with an emphasis on how to create tables, store, retrieve and update data efficiently and effectively. In addition, this module also covers more general issues such as database design principles, data independence, integrity, security, back-up and recovery, transaction, concurrency control techniques, and locking protocol. The students are expected to implement the database systems using Structured Query Language (SQL) in MySQL and spreadsheet package. This module will also introduce students to eXtensible Markup Language (XML) to structure data for storage, transport, and display.

Learning Outcomes:

On completion of the module, students will be able to:

1. Discuss the need of databases, its architecture, and schemas.
2. Design Entity Relationship (ER) models to represent database schemas.
3. Convert ER model to relational tables.
4. Populate relational database.
5. Formulate SQL queries on data.
6. Demonstrate functional dependency, primary key and relationship among tables.
7. Refine database design by normalization.
8. Construct database queries using SQL to create tables, insert and manipulate data.
9. Apply transaction in database for isolation, and authorization.
10. Design and implement database as a backend for database-centric applications.
11. Discuss distributed database systems architecture and design.
12. Create XML documents and store, transport and display data.

Learning and Teaching Approach:

Type	**Approach**	**Hours per week**	**Total credit hours**
Contact	Lecture	3	90
	Laboratory sessions	3	
Independent Study	Assignment/Project	1	30
	Self-Study	1	
Total			120

Assessment approach:

A. VLE Quiz: 10%

One quiz will be conducted on VLE upon coverage of at least 40% of the subject matter to assess the students' overall understanding of the subject matter. This quiz will contain 30 Multiple Choice Questions, each question will carry 1 mark and it will be scale-down to 10%. The test will be conducted for 30 minutes duration.

B. Class Test: 10%

One class test will be conducted upon coverage of at least 60% of the subject matter. The test will include the ER model and Normalization. The test will be conducted for 90 minutes duration. This class test will be conducted for 30 marks and later it will be scaled down to 10%.

C. Laboratory Examinations: 20%

The first laboratory examination will be conducted on the 7th week for students for a minimum of two hours and 20 marks which will be scaled down to 10% is to evaluate SQL such as Create, Alter, drop, select, Where, AND, OR, NOT, Between, Is Null, Like, In, Exists, Aggregate Functions, group by, Order by and Having clauses in the DBMS.

The second laboratory examination will be conducted on the 14th week for students for a minimum of two hours and 20 marks which will be scaled down to 10% is to evaluate SQL such as Join, subquery, correlated queries, Union, Union All, Intersect, and Minus, Triggers, Stored Procedures PL/SQL Stored Functions and Embedded SQL in the DBMS.

D. Project: 20%

One project will be given to the students in groups (3 or 4) to test students' understanding of the design and implementation of the relational database systems such as requirement analysis, conceptual diagrams, logical design, and relational design and finally implement using SQL. Each project will be awarded 100 marks and will be scaled accordingly. Each group will have to submit a report of maximum of 500 words. Each student in a group has to make one 5-7 minute presentation.

The project will be evaluated in two parts:

- Presentation: 5%
- Written report: 15%

The following marking criteria will be used to evaluate the two components:

Presentation:

i. Communication skills and self-confidence : 10%
ii. Contents : 10%
iii. Viva voce : 10%

Written report:

iv. Referencing and formatting : 5 %
v. Requirement analysis : 20%
vi. ER –diagram : 10%
vii. Normalized Tables : 15%
viii. Relational schema and SQL queries : 20%

E. Semester End Examination: 40%

The exam at the end of the semester will be a closed book for a minimum of 2 hours and 40 marks. The exam will evaluate the students' overall understanding and critical thinking ability with regards to the module.

Area of Assignments	Quantity	Weighting
A. VLE Quiz	1	10%
B. Class Test	1	10%
C. Laboratory examinations	2	20%
D. Project	1	20%
E. Semester End Examination	1	40%
Total		100%

Pre-requisites: None

Subject Matter

Unit I: Introduction & DBMS Architecture

1.1. Introduction- Data, Database, Database management system
  1.1.1. Characteristics of the database approach
  1.1.2. Role of Database administrators
  1.1.3. Role of Database Designers, End Users
  1.1.4. Advantages of Using a DBMS and When not to use a DBMS.
1.2. DBMS Architecture
1.3. Data Models
  1.3.1. Categories of Data models, Schemas, Instance, and Database states
1.4. DBMS Architecture and Data Independence
  1.4.1. The Three schema architecture
  1.4.2. Data Independence
1.5. DBMS language and interface
1.6. Classifications of Database Management Systems.

Unit II: Data Modelling Using Entity-Relationship Model

2.1. Using high level conceptual Data models for Database Design
2.2. An Example Database Application
2.3. Entity types
2.4. Entity Sets
2.5. Attributes and Keys
2.6. Relationships
2.7. Relationship types
2.8. Roles and Structural constraints
2.9. Weak Entity Types
2.10. Drawing E- R Diagrams.

Unit III: Database Design

3.1. Introduction to Logical Database Design
3.2. Relational Data Model

3.3. Super Key, Candidate Keys, Primary Key
3.4. Codd's Rules
3.5. Relational Algebra
3.6. Integrity Constraints
3.7. Transforming ER diagrams into relations
3.8. Functional Dependencies
3.9. Normalization – 1NF, 2NF, 3NF, BCNF and 4NF

Unit: IV System Implementation & Transaction Processing

4.1. Introduction to SQL
  4.1.1. Inserting, Updating, and Deleting data
  4.1.2. Processing Single Tables
  4.1.3. Manipulation Data in SQL
4.2. Processing Multiple Tables
  4.2.1. Joining Multiple Tables (Equi Joins)
  4.2.2. Joining a Table to itself (self Joins)
  4.2.3. Sub queries Union
  4.2.4. Intersect & Minus Clause
4.3. Creating view
  4.3.1. Renaming the Column of a view
  4.3.2. Updating, Selection, Destroying view
  4.3.3. Granting Permissions
4.4. PL/SQL Constructs Views
  4.4.1. Creating Indexes
  4.4.2. Triggers
4.5. PageRank

Unit: V Transaction Processing Concepts and Concurrency Control

5.1. Transaction and System concepts
  5.1.1. Desirable properties of Transactions
  5.1.2. Schedules and Serializability Issues
  5.1.3. Recoverability
5.2. Lock-Based Protocols
  5.2.1. Locks, Granting of Locks
  5.2.2. Two phase locking protocol.
5.3. Introduction to MapReduce programming model

Unit: VI XML

6.1. Introduction to XML
6.2. Uses of XML
6.3. XML key components
6.4. Document Type Definition (DTD) and Schemas

Unit: VII Distributed Databases

7.1 Distributed database concepts
7.2 Data fragmentation
7.3 Replication
7.4 Allocation Techniques for Distributed database design
7.5 Types of Distributed database systems

List of Laboratory sessions:

1. Create a sample database (e.g., employee, bank, university).

2. Use Data Definition commands to create tables and constraints in tables.
3. Use Data Manipulation commands for insert, delete, update, and list rows from table.
4. Use where, order, having, join clauses with logical operators and special operators to retrieve data from tables.
5. Use relational operators and sub query operators to join tables.
6. Write queries using R/Excel to retrieve, view, insert and analyze data from the backend database.
7. Use Procedural SQL to automate query, transform and update data in the database.
8. Create XML document to represent data.

Reading List:

Essential Reading:

Elmasri, R., & Navathe, S. B. (2016). *Fundamentals of Database Systems* (7 ed.). Pearson.

Chaudhri, A. B., Rashid, A., & Zicari, R. (2003). *XML data management: Native XML and XML-enabled database systems*. Addison-Wesley Professional.

Silberschatz, A., Korth, H. F., & Sudarshan, S. (2010). DatabaseSystem Concepts.

Additional Reading:

Ramakrishnan, R., & Gehrke, J. (2000). *Database management systems*. McGraw Hill.

Deitel, P., & Deitel, H. (2007). *Internet & world wide web: how to program*. Prentice Hall Press.

Williams, K., Brundage, M., Dengler, P., Gabriel, J., Hoskinson, A., Kay, M. R. & Vanmane, M. (2000). *Professional XML databases*. Birmingham, UK: Wrox press.

Date: March, 2022

ECO101: Fundamentals of Economics

Module Code and Title: ECO101 Fundamentals of Economics
Programme: BA in Population and Development Studies
Credit Value: 12
Module Tutor: Tashi Dorji, Dr. Kalish Pati
Module Coordinator: Tashi Dorji

General Objective

This module aims to provide students with an understanding of the fundamental principles of economics. Students will learn how to apply economic theory to questions of government, business and household management, with how markets work and how economic relations affect the wider organization of society.

Learning Outcomes

On completion of the module, students will be able to:

1. Explain the basic economic concepts.
2. Describe the basic components of economic theories.
3. Relate the demand and supply theories in current market context.
4. Explain the role of financial, fiscal and monetary policy.

5. Illustrate the linkages between poverty, unemployment and inflation.
6. Explain the economic and development policies of Bhutan.
7. Discuss the concept of welfare state, fiscal spending and revenue.

Learning and Teaching Approach

Approach	Hours per week	Total credit hours
Lecture	3	45
Tutorial	1	15
Assignment	2	30
Independent Study	2	30
Total		**120**

Assessment Approach
Assessment will be carried on a continuous basis through the following assignments:

A. Assignment (20%):
Students have to write two assignments. Each assignment carries 10 percent. The assignment topics will be determined by the concerned module tutor.

- Content (relevancy of the content and originality): 5%
- Organization and language (clarity and flow, use of appropriate words and grammar, presentation): 3%
- Proper Referencing and Citation: 2%

B. Class test (10%):
Class test will be conducted after completion of 50% of the module for duration of one hour.

C. Quiz (10%):
Quiz will be conducted after completion of the module. The question should cover all the units prescribed in the module descriptor. This will help students to prepare for Semester End Examination.

D. Semester End Examination (60%):
Students have to write end-semester with students of other programme

Overview of Assessment Approaches

Areas of Assessment	Quantity	Weighting
A. Assignment	2	20%
B. Class test	1	10%
C. Quiz	1	10%
D. Semester-end Examination	1	60%

Pre-requisite: None

Subject Matter
Unit I: Introduction
1.1. Introduction to economic concepts and terminology
1.2. Demand, supply and market
  1.2.1. Demand and Supply Curve
  1.2.2. An individual demand and supply for product

1.2.3. The market demand and supply curve
1.2.4. Movement along and shifts in demand and supply curve
1.3. Elasticity of demand and supply
1.3.1. Price elasticity of Demand and Supply
1.3.2. Coefficient of Price elasticity
1.3.3. Elasticity and total revenue
1.3.4. Factors affecting price elasticity
1.3.5. Price, cross-elasticity of demand
1.3.6. Income elasticity of demand
1.3.7. Calculation of marginal revenue
1.3.8. The geometry of marginal revenue determinants
1.3.9. The MRC lies below the demand curve
1.3.10. Elasticity and Marginal Revenue

Unit II: Microeconomics

2.1. Consumer Choice and demand decision
2.2. Supply decisions
2.3. Costs and supply
2.4. Perfect competition and pure monopoly
2.5. Market structure and imperfect competition
2.6. The labor markets
2.7. Different types of labor
2.8. Factor markets and income distribution
2.9. Risk and information

Unit III: Macroeconomics

3.1. Introduction to macroeconomics
3.2. Output and aggregate demand
3.3. Fiscal policy and foreign trade
3.4. Money and Banking
3.5. Interest rates and monetary transmission
3.6. Monetary and fiscal policy
3.7. Aggregate supply, prices and the adjustment to shocks
3.8. Inflation, expectations, and credibility
3.9. Unemployment
3.10. Exchange rates and balance of payments
3.11. Open economy macroeconomics
3.12. Economic growth
3.13. Business cycles

Unit IV: Welfare state

4.1. Introduction to welfare economics
4.2. Government spending and revenue
4.3. Industrial policy and competition
4.4. Natural monopoly: Public or private

Reading List

Essential reading

Begg, D., Fischer, S., & Dornbusch, R. (2008). *Economics* (9th edition). McGraw-Hill Contemporary.

Bodman, D. (2002). *Macroeconomics*. McGraw-Hill Europe.
Charlé, E. (1983). *Macroeconomics of developing countries*. Tata McGraw-Hill. Lipsey, R. G., & Chrystal, K. A. (1999). *Principles of Economics* (9 edition). Oxford University Press.
Mankiw, N. G. (2015). *Macroeconomics*. New York: Worth Publishers.
Mankiw, N. G. (2014). *Principles of Macroeconomics*. Australia: South-Western College Pub.
NSB (2017). *Consumer price Index bulletin January 2017*. National Accounts and Price Division, NSB

Additional Reading

Katz M. L., & Rosen, H. S. (1991). *Microeconomics. Richard D*. McGraw Hill. Koutsoyiannis, A. (2001*). Modern Micro Economics*. ELBS.
Pindyck, R. S., & Rubinfeld, D. (1999*). Micro Economics*. McGraw Hill. Varian, H. (1998). Intermediate Micro Economics. WW Norton www.nsb.gov.bt

Date: October 29, 2016

Year 2: Semester II

DST204: Probability Distributions II

Module Code & Title: DST204 Probability Distributions II
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

The objective of the module is to introduce the basic concepts of various truncated and compound statistical distributions of random variables. This module will also help the students understand the sampling distributions and non-central distributions using spreadsheet.

Learning Outcomes

On completion of the module, students will be able to:

1. Solve problems related to truncated and compound statistical distributions of random variables.
2. Apply the sampling distributions of correlation coefficient, regression coefficient.
3. Apply the sampling distributions of correlation ratio, intra class correlation coefficient.
4. Evaluate the idea regarding non-central t, χ^2 and f distributions.
5. Plot and interpret the orthogonal polynomials and Pearsonian curves.
6. Apply the variance stabilizing transformations to random variables.
7. Test for normality of random variable.
8. Test the significance based on distributions.
9. Explain order statistics, distribution of r^{th} order statistics.
10. Estimate the parameters of the various continuous probability distributions.
11. Apply the different distributions for modelling the real datasets.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours

Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (10%)**

The assignment will be completed during the first half of the semester. The main objective of this assignment is to verify whether students have understood the concepts taught in the class. Set of questions based on the topics covered will be provided to the students. Students will have to exhibit their understanding of the concepts through their solutions to the questions. It is an individual work and each student will have to make their submission. In order to avoid plagiarism different sets of questions with same difficulty level will be given to the students. The assignment will be evaluated based on the following criteria:

- Correctness of the solutions: 40%
- Logical flow in the process: 20%
- Uniqueness of the solution: 20%
- Use of appropriate terms and symbols: 20%

The final mark achieved will be converted to 15%.

If it is confirmed that a student has plagiarized the assignment, then as per the academic norm, the student will be awarded zero mark or made to redo the assignment based on the convenience of the tutor. In the event where plagiarism is suspected but could not be confirmed, the student in question will be called for viva-voice or asked for oral presentation of the solution. Based on the viva-voice or oral presentation, the tutor will either maintain the initial mark or reduce it.

B. **Laboratory: (15%)**

Laboratory assessment will be carried out as follows:

- **Laboratory report – 5%**

  Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. Students will submit minimum of 10 laboratory reports with 250-500 words in each report.

  The criteria for laboratory report evaluation are as follows:

  - Objective : 1%
  - Methods : 2%
  - Results : 1%
  - Conclusion/ Interpretation : 1%

  This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam – 10%**

  A laboratory exam for the duration of 2 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matters being covered for the duration of 3 hours. The final mark obtain in the mid semester Examination will be converted to 15%.

D **Semester-end Examination: (60%)**
Semester end Examination will be conducted on 100% coverage of the syllabus and weightage will depend on content in each unit. Exam will be conducted for the duration of three hours' worth of 60%.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Laboratory report	10	5%
	Laboratory Exam	1	10%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	60%

Prerequisites: DST103 Probability Distributions I

Subject Matter

Unit I: Special Continuous Distributions and Properties

1.1 Truncated and compound distributions.
1.2 Fitting of orthogonal polynomials.
1.3 Pearsonian curves.
1.4 Categorical data analysis - log linear models.
1.5 Variance stabilizing Transformations.
1.6 Sampling distribution of correlation coefficient.
1.7 Sampling distributions of regression coefficient, correlation ratio, intra class correlation coefficient

Unit II: Non-Central Distributions

2.1 Non-central t, χ^2 and F distributions.
2.2 Distribution of quadratic forms.
2.3 State and prove Cochran's theorem.
2.4 Tests for normality.
2.5 Large sample tests.
2.6 Tests of significance based on t, $\chi^2$and F distributions

Unit III: Order Statistics

3.1 Concepts of Order statistics.
3.2 Order statistics sampled from a uniform distribution
3.3 Joint distribution of order statistics of uniform distribution
3.4 Order statistics sampled from an exponential distribution
3.5 Order statistic sampled from an Erlang distribution
3.6 Distribution of rth order statistics, joint distribution of several order statistics.
3.7 Marginal distributions of order statistics.
3.8 Distribution of range, median etc.

List of Laboratory sessions

1. Truncated probability distributions
    a. Calculate the general probability
    b. Creating simple probability distribution
    c. Fitting the distribution
    d. Generate a random sample for the distribution with parameter size and probability

    e. Calculate the expectation and variance
2. Fitting of discrete orthogonal polynomial
3. Fitting of continuous orthogonal polynomials
4. Fitting log linear models
5. Variance stabilizing transformations in relative variance and absolute plus relative variance
    a. Calculate the general probability
    b. Creating simple probability distribution
    c. Fitting the distribution
    d. Calculate the expectation and variance
6. Non-Central distributions.
    a. Calculate the general probability
    b. Creating simple probability distribution
    c. Fitting the distribution
    d. Calculate the expectation and variance
7. Order statistics
    a. Calculate the general probability
    b. Creating simple probability distribution
    c. Fitting the distribution
    d. Generate a random sample for the distribution with parameter size and probability
    e. Calculate the expectation and variance

Reading List

Essential Reading

Agresti, A. (2002). *Categorical Data Analysis*, John Wiley, New Delhi.

David, H. A., and Nagaraja, H. N. (2003). *Order Statistics*, John Wiley, New Delhi.

Hogg, R. V., and Craig, T. T. (2019). *Introduction to Mathematical Statistics*, Prentice-Hall, New Delhi.

Johnson, N. L., Kotz, S., and Balakrishnan, N. (2000). *Continuous Univariate Distributions*, John Wiley, New Delhi.

Mood, A. M., Graybill, F. A., and Boes, D. C. (2001). *Introduction to Theory of Statistics*, TMH Publishing Co.Ltd., New Delhi.

Additional Reading

Arnold, B. C., Balakrishnan, N., and Nagaraja, H. N. (2008). *A First Course in Order Statistics*, John Wiley, New Delhi.

Dudewicz, E. J., and Mishra, S. N. (1988). *Modern Mathematical Statistics*, John Wiley, New Delhi.

Hoel, P. G. (1984). *Introduction to Mathematical Statistics*, John Wiley, New Delhi.

Rao, C. R. (2001). *Linear Statistical Inference and its Applications*, John Wiley, New Delhi.

Rohatgi, V. K., & Saleh, A. K. Md. E. (2015). *An Introduction to Probability and Statistics*, John Wiley, New Delhi.

Searle, S. R. (2016). *Linear Models*, Academic Press, New Delhi

Date: December, 2021

AMT210: Numerical Methods

Module Code & Title: AMT210 Numerical Methods
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Pema Tshering

General Objective
The module provides the numerical methods of solving the non-linear equations, interpolations of polynomials, differentiation, and integration. The module will help the students' to improve skills in numerical methods by using Python programming.

Learning Outcomes
On completion of the module, students will be able to:
1. Apply the concepts of error and its sources in solving problems.
2. Apply various numerical methods to solve equations.
3. Identify different methods for solving non-linear equations.
4. Solve a function using interpolation techniques.
5. Calculate derivative of a function numerically.
6. Identify appropriate methods to integrate a function.
7. Examine direct and iterative methods to solve system of linear equations.
8. Transform symmetric matrices into tridiagonal matrices using different methods.
9. Evaluate Eigen values of the tridiagonal matrices.
10. Evaluate Eigenvalues and eigenvectors using symmetric orthogonal matrices.

Learning and Teaching Approach

Type	**Approach**	**Hours per week**	**Total credit hours**
Contact	Lecture	4	**75**
	Laboratory sessions	1	
Independent Study	Written assignment	1	**45**
	Self-study	2	
Total			**120**

Assessment Approach
A. Assignment: (15%)
An individual assignment will be given to the students before mid-semester examination. The assignment will comprise of problem solving and it will be evaluated broadly on the following criteria:
- Solving non-linear equations mathematically and using python 4 marks
- Solving functions using interpolation techniques 4 marks
- Fitting linear and non-linear curves 3 marks
- Integration and differentiation of functions using various methods 4 marks

B. Class Test: (10%)
A class test of one hour duration will be conducted before the semester end examination and the questions will be from the subject matters covered after the mid semester examination.

C. Lab Exam: (10%)
A laboratory exam for the duration of 2 hours will be conducted towards the end of a semester after the last day of regular teaching. The objective of the laboratory exam is to test the understanding of the concepts taught. Students will have to use Python to evaluate numerical solutions to some of the concepts listed in the list of laboratory sessions. The evaluation will be based on the solution to laboratory exam questions.

D. Mid-Semester Examination: (15%)

Mid-Semester examination will be of one and half hours duration with at least 60% of subject matter included. The total weighting of the examination paper will be 40 and the marks obtained will be converted into 15.

E. Semester-end Examination: (50%)

Semester end Examination will be conducted for the duration of two and half hours and questions will be from all the units of the subject matter of the module. The total weighting of the examination paper will be 50. Test blue print of the question paper and an answer key for grading will also be prepared along with the question paper.

Overview of Assessment Approaches

Areas of assignments	Quantity	Weighting
A. Assignment	1	15%
B. Class Test	1	10%
C. Laboratory exam	1	10%
D. Mid-Semester Examination	1	15%
E. Semester-end Examination	1	50%

Prerequisite: PLT102: Programming in Python

Subject matter

Unit I: Errors

1.1 Definition and source of errors
1.2 Significant error
1.3 Error in numerical computations

Unit II: Solutions of non-linear equations (Algorithm and Problem solving)

2.1 The Bisection method
2.2 Method of false-position
2.3 The Secant method
2.4 Muller's method
2.5 Fixed point iterative method
2.6 Newton-Raphson's method
2.7 Graffe's method

Unit III: Interpolation and curve fitting

3.1 Lagrange's interpolation (Algorithm and Problem solving)
3.2 Newton's divided difference interpolation (Algorithm and Problem solving)
3.3 Newton's forward and backward difference interpolation (Algorithm and Problem solving)
3.4 Central difference interpolation:(Discuss algorithm and Problem solving)
    3.4.1 Bessel's interpolation
    3.4.2 Stirling's interpolation
    3.4.3 Gauss' interpolation
    3.4.4 Everett's interpolation
3.5 Hermite interpolation (Algorithm and Problem solving)
3.6 Cubic Spline interpolation (Algorithm and Problem solving)
3.7 Chebyshev Interpolation polynomial (Algorithm and Problem solving)
3.8 Least-squares curve fitting (Algorithm and Problem solving)

3.9 Fitting linear and non-linear curves (Algorithm and Problem solving)
3.10 Polynomial Approximations (Algorithm and Problem solving)
3.11 Orthogonal Polynomials (Algorithm and Problem solving)

Unit IV: Numerical Differentiation and Integration

4.1 Numerical Differentiation(Discuss algorithm and Problem solving)
- 4.1.1 Newton's forward differentiation
- 4.1.2 Newton's backward differentiation
- 4.1.3 Central formula differentiation

4.2 Numerical Integration: (Algorithm and Problem solving)
- 4.2.1 Rectangular rule
- 4.2.2 Trapezoidal rule
- 4.2.3 Simpson rule
- 4.2.4 Boole's rule
- 4.2.5 Weddle's rule
- 4.2.6 Gaussian quadrature formula
- 4.2.7 Errors in Gaussian quadrature formula

Unit V: System of Linear Equations

5.1 Direct Methods:(Algorithm and Problem solving)
- 5.1.1 Gaussian Elimination method
- 5.1.2 Gauss-Jorden Method
- 5.1.3 LU Decomposition method
- 5.1.4 Cholesky method
- 5.1.5 Matrix inversion method

5.2 Iterative Methods:(Algorithm and Problem solving)
- 5.2.1 Jacobi's Method
- 5.2.2 Gauss-Seidel Method
- 5.2.3 Relaxation method

Unit VI: Eigen Values and Eigen vectors (Algorithm and Problem solving)

6.1 Jacobi's method
6.2 Power method
6.3 Given's method
6.4 Householder's method
6.5 The QR method
6.6 Lanczo's method

Unit VII: Ordinary Differential Equations

7.1 Picard's method
7.2 Taylor's series method
7.3 Euler's method
7.4 Modified Euler's method
7.5 Ranga Kutta Methods
7.6 Adams-Bashford Methods
7.7 Adams-Moulton methods
7.8 Milne-Simpson's Method

List of Laboratory Sessions

The laboratory sessions will help the students to understand the concepts well. They will be taught how to compute and analyze solutions to some of the numerical problems using Python. Students are expected to use Python to evaluate the following problems:

1. Zero of nonlinear functions.
2. Roots of polynomials using Newton Raphson model.
3. Interpolation with polynomials.
4. Interpolation with splines.
5. Interpolation and approximation with trigonometric polynomial.
6. Integration with simple and composite newton's cotes formula.
7. Integration with Gaussian quadrature formula.
8. Gaussian Elimination.
9. Triangular factorization.
10. Gauss-Seidel method.
11. Relaxation method.
12. Jacobi method.
13. Transformation of symmetric matrix to tridiagonal matrix.

Reading List

Essential reading

Gerald, C.F. & Wheatley, P. O. (2013): *Applied Numerical Analysis*. Dorling Kindersley (India) Pvt. Ltd.

Greenbaum A. & Chartier T. P. (2012). *Numerical Methods: Design, Analysis and Computer Implementation of algorithms*. Princeton University Press.

Burden, R.L. & Faires, J.D: *Numerical Analysis.* (9 ed.). Brooks/Cole Publishing Company

Additional reading

Atkinson, K.E. An Introduction to Numerical Analysis. (2 ed.). John Wiley & Sons.

Sastry, S. S. (2000): *Introductory Methods of Numerical Analysis*. Asoke K. Ghosh, Prentice-Hall of India Private Limited

Prasad, D. (2012): *An Introduction to Numerical Analysis*. Narosa Publishing House Pvt. Ltd.

Date: March, 2022

ANY207: Real Analysis

Module Code & Title: ANY207 Real Analysis
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Pema Tshering

General Objective

This module is designed to provide fundamental concepts of analysis, including the basic properties of different subsets, classical theory of functions of a real variable, continuity and differentiation of real valued functions. The students will be exposed to the concepts of sequence and infinite series.

Learning Outcomes

On completion of the module, students will be able to:

1. Find upper and lower bounds of a set.
2. Define complete ordered field.
3. Explain the order completeness property of set of real numbers.
4. Check whether the given subset of set of real numbers is closed, open or neither.
5. Find the limit of a convergent sequence.
6. Apply various tests to check the convergence of infinite series.
7. Explain the concepts of a limit of a function at a point.
8. Distinguish between continuous and discontinuous functions.
9. Verify the mean value theorems for a given function in a given interval.
10. Evaluate extreme values of functions.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. Assignment: (15%)

One assignment will be given before the mid-semester examination and the assignment will comprise of problem solving. The questions will be from the units I and II. The students have to solve the problems individually. The assignment will be evaluated broadly on the following criteria:

- Finding upper and lower bounds of a set 3 marks
- Checking the given set for close and open 4 marks
- Checking for the convergence of sequence 4 marks
- Checking for the convergence of a series using various test. 4 marks

B. Class test: (10%)

A class test of one hour duration will be conducted before the semester end examination. The questions will be from the subject matters covered after the mid-semester examination.

C. Mid-Semester Examination: (15%)

Mid-Semester examination will be of one and half hours duration with at least 60% of the module content included. The total weighting of the examination paper will be 40 and the marks obtained will be converted into 15.

D. Semester-end Examination: (60%)

Semester-end Examination will be conducted for the duration of 3 hours and questions will be from all the units of the subject matter of the module. The total weighting of the examination paper will be 60. Test blue print of the question paper and an answer key for grading will also be prepared along with the question paper.

Overview of Assessment Approaches

Areas of assignments	Quantity	Weighting
A. Assignment	1	15%
B. Class test	1	10%
C. Mid-semester Examination	1	15%
D. Semester end Examination	1	60%

Pre-requisites: AMT209 Mathematical Logic

Subject Matter

Unit I: Limit points

1.1 Bounded and Unbounded sets: supremum and infimum (Theorems with proof)
1.2 Completeness in the set of real numbers (Theorem with proof)
1.3 Archimedian property of real numbers (Theorem with proof)
1.4 Neighbourhood of a point (Theorems with proof)
1.5 Interior points, interior of a set (Theorems with proof)
1.6 Open sets (Theorems with proof)
1.7 Limit points of a set (Theorems with proof)
1.8 Closed sets. (Theorems with proof)

Unit II: Sequence and Series

2.1 Sequences
2.2 Convergence of sequences
2.3 Limit points of a sequence
2.4 The limit superior and the limit inferior
2.5 Convergent Sequences (Theorems and Proof)
2.6 Non- Convergent Sequences
2.7 Cauchy's General Principle of convergence for series and sequence (with proof)
2.8 Monotonic sequences (Theorems and proof)
2.9 Infinite series
2.10 Convergence of series (Definition)
    2.10.1 Conditional convergence (Definition)
    2.10.2 Absolute convergence (Definition)
2.11 Positive term series
2.12 Various Tests for convergence of series (with proof)
    2.12.1 Comparison test
    2.12.2 D'Alembert Ratio test
    2.12.3 Root test
    2.12.4 Cauchy Integral test
    2.12.5 Raabe test

2.13 Alternating series
    2.13.1 Libnitz's test (With proof)
    2.13.2 Conditional Convergence
    2.13.3 Absolute Convergence

Unit III: Continuity

3.1 Limits (Theorems and Proof)
3.2 Interchange of limits
3.3 Continuous functions (Theorems and Proof)

3.4 Discontinuous functions
3.5 Uniform continuity and pointwise continuity (Theorems and Proof)

Unit IV: The Derivative
4.1 Differentiability of a function (Theorems and Proof)
4.2 Increasing and decreasing functions (Theorems and Proof)
4.3 Chain Rule
4.4 Rolle's theorem (with proof)
4.5 Mean value theorems (with proof)
4.6 Higher order derivatives
4.7 Talyor's theorem (with proof)
4.8 Infinite Taylor expansion (with proof)
4.9 L'Hopital's Rule (with proof)
4.10 Maxima and minima of functions

Reading List
Essential Reading
Malik, S.C. *Principles of Real Analysis.* New Delhi: New Age International pvt ltd.
Robert G. Bartle & Donald R. Sherbert. (2011). *Introduction to Real Analysis.* (4th ed.). New Delhi: Willey India Private Limited.`
Additional Reading
Apostol, M. T. (1997). *Mathematical Analysis*. New Delhi: Narosa Publishing House
Narayan, S. (1998). A module of Mathematical Analysis. (12th revised ed.). New Delhi: S. Chand & Company.
Royde, H. L. (1988). *Real Analysis*. (3rd ed.). London: Collier-Macmillan International.
Rudin, W. *Principles of Mathematical Analysis.* New York: McGraw-Hill.

Date: March, 2022

IST201: Sampling Theory
Module Code & Title: IST201 Sampling Theory
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung
General Objective
This module is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data using Spreadsheets and R. The students would also be exposed to the real-life applications of sampling techniques and estimation of parameters.

Learning Outcomes
On completion of the module, students will be able to:
1. Compare basic concepts of various sampling techniques.
2. Explain the importance of sampling over complete enumeration in many situations of practical importance.
3. Apply simple random sampling for real datasets.

4. Differentiate ratio, difference and regression estimators for estimation of population mean or population total.
5. Distinguish between cluster sampling, stratified and systematic sampling procedures.
6. Estimate the proportions and confidence intervals.
7. Determine the sample size of a sample.
8. Implement the concepts of inverse sampling for rare phenomena.
9. Differentiate between sampling and non-sampling error.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (10%)**

The assignment will be completed during the first half of the semester. Set of questions (not over 10) based on the first 3 units covered will be provided to the students. Students will have to exhibit their understanding of the concepts through their solutions to the questions. It is an individual work and the date of submission will be two weeks from the given date. In order to avoid plagiarism different sets of questions with same difficulty level will be given to the students. The assignment will be evaluated based on the following criteria:

- Correctness of the solutions: 4 marks
- Logical flow in the process: 2 marks
- Uniqueness of the solution: 2 marks
- Use of appropriate terms and symbols: 2 marks

If it is confirmed that a student has plagiarized the assignment, then as per the academic norm, the student will be awarded zero mark or made to redo the assignment based on the convenience of the tutor. In the event where plagiarism is suspected but could not be confirmed, the student in question will be called for viva-voice or asked for oral presentation of the solution. Based on the viva-voice or oral presentation, the tutor will either maintain the initial mark or reduce it.

B. **Laboratory Assessment: (15%)**

The laboratory assessment will be carried out as follows:

- **Laboratory report -5%**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam -10%**

A laboratory examination for the duration of 2 hours will be conducted towards the end of the semester after the last day of regular teaching.

C. **Mid-Semester Examination: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of 3 hours. Examination will be conducted out of 60 marks and one-fourth of the scores will be taken as final score.

D. **Semester-end Examination: (60%)**

Semester end Examination for the duration of three hours and will be for 60 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments	Approach	Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Laboratory Report	10	5%
	Laboratory Exam	1	10%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	60%

Pre-requisites: PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Introduction to Sampling

1.1 Notion of sample and population
1.2 Complete enumeration versus sampling
1.3 Types of sampling: non-probability and probability sampling
1.4 Basic principle of sample survey

Unit II: Simple Random Sampling

2.1 Definition and procedure of selecting a sample
- 2.1.1 Population and unit, finite and infinite population
- 2.1.2 Sampling frame
- 2.1.3 Parameter and parameter space
- 2.1.4 Complete enumeration and sample survey
- 2.1.5 Sampling and non-sampling errors

2.2 Simple random sampling (SRS) with replacement
- 2.2.1 Sampling scheme
- 2.2.2 Estimation of population mean and variance
- 2.2.3 Estimation of population proportion

2.3 Simple random sampling without replacement
- 2.3.1 Sampling scheme
- 2.3.2 Estimation of population mean and variance
- 2.3.3 Estimation of population covariance
- 2.3.4 Estimation of population proportion
- 2.3.5 Estimation of domain mean and total

2.4 Sample size determination

2.4.1 Consideration of cost of a survey
2.4.2 Consideration of the efficiency of estimator with given variance or coefficient of variation or margin of permissible error

Unit III: Sampling Techniques

3.1 Stratified random sampling technique
- 3.1.1 Definition and advantages of stratified random sampling
- 3.1.2 Estimation of population mean
- 3.1.3 Estimation of population proportion

3.2 Different allocations and their comparison with SRS
3.3 Systematic Sampling technique
- 3.3.1 Linear systematic sampling
- 3.3.2 Efficiency of systematic sampling
- 3.3.3 Circular systematic sampling

3.4 Estimates of population mean and total
3.5 Variances of estimates of population mean and total
3.6 Comparison of systematic sampling with SRS and stratified sampling

Unit IV: Other Sampling Techniques

4.1 Inverse sampling technique
4.2 Cluster sampling technique
4.3 Ratio, difference and regression estimators
4.4 Multi-stage sampling with equal probability
4.5 Double sampling
4.6 Successive sampling

Unit V: Sampling and Non-sampling errors

5.1 Sampling errors: sources and classification
5.2 Non-sampling errors: sources and classification
5.3 Non-response survey techniques
5.4 Imputation techniques
5.5 Measurement errors
5.6 Repeated measurement techniques

List of Laboratory Sessions

1. Estimation of proportions and confidence interval of estimators
2. Determination of Sample size in various sampling
3. Laboratory session on Inverse sampling, stratified sampling, Cluster sampling
4. Non-response survey techniques, Imputation techniques

Reading List

Essential Reading

Cassel, C. M., Sarndal, C. E., and Wretman, J. H. (1992). *Foundations of Inference in Survey Sampling*, John Wiley, New Delhi.

Chaudhari, A., and Stenger, H. (2005). *Survey Sampling Theory and Methods*, Chapman and Hall, New Delhi.

Chaudhari, A., and Voss, J. W. E. (1988). *Unified Theory and Strategies of Survey Sampling*, North Holland, New Delhi.

Cochran, W. G. (2005). *Sampling Techniques*, John Wiley, New Delhi.

Murthy, M. N. (1977). *Sampling Theory and Methods*, Statistical Publishing Society, Kolkatta.

Additional Reading

Hansen, M. H., Hurwitz, W. H., and Madow, W. G. (1993). *Sample Survey Methods and Theory*, Vol. I and Vol. II., John Wiley, New Delhi.

Hedayat, A. S., and Sinha, B. K. (1991). *Design and Inference in Finite Population Sampling*, John Wiley, New Delhi.

Singh, D., and Chaudhary, F. S. (2020). *Theory and Analysis of Sample Survey Designs*, New Age International Pvt. Ltd., New Delhi.

Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., and Asok, C. (1984). *Sampling Theory of Surveys with Applications*, Indian Society of Agricultural Statistics, New Delhi.

Thompson, S. K. (2012). *Sampling*, John Wiley, New Delhi.

Date: March, 2022

GSE101: Analytical Skills

Module Code and Title **:** GSE101 Analytical Skills
Programme **:** University-wide module
Credit **:** 12
Module Tutors **:** Sangay Thinley

General Objective

The module aims at developing critical and analytical thinking skills of students to enhance their creativity and ability to think laterally that will aid problem solving and decision-making abilities. With these essential analytical thinking and problem-solving skills students gain an edge in a competitive world.

Learning outcomes

On completion of the module, students will be able to:

- articulate thinking paradigms;
- explain creativity and barriers to creative thinking;
- apply creative thinking skills to spot unnoticed opportunities;
- describe problem solving process;
- apply appropriate problem-solving tools to a given issue;
- evaluate issues to make informed decisions;
- generate creative solutions by using appropriate methods.

Teaching and learning approaches

Approach	Hours per week	Total Credit Hours
Lectures	1	15
Group and Panel Discussions, Presentations, Case Study	1	15

Role Plays/Demonstrations, Mock sessions, Audio visuals	2	30
Independent Study, Reflection, Written Assignments, Project Work , Individual Reading	4	60
Total		**120**

Assessment approach

A. Written Assignment: Portion of final Marks-20%

Students will be required to complete one written assignment on the contemporary issue of a subject. The required data and contextual information will be provided to students. Students will be required to read, analyse and interpret the data and contextual information, and communicate the result to the intended audience. Wherever there is a need, students should substantiate the existing data with their own data collection. The length of the assignment should be anywhere between 1000 and 1500 words.

Criteria:
4%-Originality and creativity
2% -Clarity of the points and opinions
4% -Reliability of data and accuracy of data interpretation
8%- Analysis of the issue
2% -Overall effectiveness of writing style

B. Class Participation: Portion of the final Marks-10%

Students will participate in class discussions, contributing their ideas and opinions about the methods and tools being taught in the module.

Criteria:
2%-frequency of participation in class
3%-quality of comments –involving critical thinking and analysis of information and reasoning
5%-contribution in a group discussion in class –understanding of group dynamics and processes

C. Case Analysis and Presentation: Portion of Final Marks-30%

Students will solve one case study in a group which will be assessed in two components. The case can be related to any field of knowledge such as engineering, climate change, biotechnology, sustainable development, procurement, production, marketing, strategic management, human resource and current economic and social development.

1. **Written**
   Criteria:
   5% identifying the problem
   10% choosing the right approach for the analysis and solving the problem
   5% drawing the correct conclusion with a recommendation
2. **Presentation**
   Criteria:
   2% Creativity in delivery of the presentations;

2% Visual appeal
2% Confidence
4% Content analysis

D. Panel Discussion: Portion of Final Mark-20%

A group of students will be required to discuss a topical issue such as climate change, green procurement, disruptive innovation, and big data moderated by a peer.
Criteria:
5% Preparedness on the topic
5% Relevance of the argument
5% Respect for other panelist views
5% Coherent and logical flow of ideas

E. Debate: Portion of the Final Mark-20%

Students in groups of four or five will debate on a given topic against another group.
Criteria:
5%-Language Proficiency
5%-Intelligence, ability and competence
5%-Logical thinking and reasoning
5%-Ability to use appropriate information

Overview of the assessment approaches and weighting

Areas of Assignment	**Quantity**	**Weighting**
A. Written Assignment	1	20%
B. Class Participation	NA (non-definite/should participate in the class discussion at least 5 times)	10%
C. Case Analysis & Presentation	1 + 1	30%
D. Panel Discussion	1	20%
E. Debate	1	20%
TOTAL		**100%**

Pre-requisite: None

Subject matter

UNIT I: Thinking process & Reflection

1.1. Introduction to the Thinking Process & Reflection
1.2. Concept of mind mapping
1.3. Metacognition and thinking about thinking
1.4. Thinking Paradigms: Lateral and Vertical thinking
  1.4.1. Whole brain (system 1 and system 2)
  1.4.2. Analytical

1.4.3. Critical
1.4.4. Creative
1.4.5. Logical
1.4.6. Scientific
1.4.7. Statistical
1.4.8. Systems
1.4.9. Visual
1.4.10. Ethical

UNIT II: Overview of analytical thinking skills

2.1. Concept of analytical skills
2.2. Competencies of analytical thinking
2.3. Benefits of analytical thinking
2.4. Analytical thinking process
2.5. Tools and techniques for analytical skills
2.6. Application of analytical thinking
2.7. Validity and strength in arguments

UNIT III: Creative Thinking

3.1. Definition of creativity
3.2. Creative thinking – Self-Assessment
3.3. Characteristics of a creative person,
3.4. Barriers to creativity and overcoming the barriers
3.5. Ways to enhance creative thinking (e.g. brain storming)
3.6. Methods of creativity

UNIT IV: Problem solving process

4.1 Understanding problem analysis
4.2 Conventional problem solving process
- 4.2.1 Present the problems
- 4.2.2 Ask solutions
- 4.2.3 Shoot down ideas
- 4.2.4 Make consensus

4.3 Creative problem-solving process
- 4.3.1 Problem definition
- 4.3.2 Problem analysis
- 4.3.3 Generating possible solutions
  - 4.3.3.1 Brain storming process and rules
  - 4.3.3.2 Fishbone Analysis
  - 4.3.3.3 Mind mapping
- 4.3.4 Analysing the solutions
- 4.3.5 Selecting the best solution
- 4.3.6 Implementing the best solution
- 4.3.7 Planning the next course of action

4.4 Questioning techniques

UNIT V: Decision making process

5.1. Introduction to Decision making process
5.2. Six Thinking Hats
5.3. SWOT Analysis
5.4. Decision Tree analysis/what-if analysis
5.5. Pareto chart
5.6. Logical Framework Analysis

Reading List

Essential Reading

Bano, E. d. (2000). *Six Thinking Hats* (2nd ed.). New Delhi, India: Penguin India.

Michalko, M. (2006). *Thinkertoys: A handbook of creative-thinking techniques* (2nd ed.). Ten Speed Press.

Puccio, G.J., Mance, M. & Switalski, L.B. (2017). *Creativity Rising Creative Thinking and Creative Problem Solving in the 21st Century.* ICSC Press, International Center for Creativity, US

Treffinger, D. J. (2006). *Creative Problem Solving: An introduction* (4th ed.). Prufrock.

Additional Reading

Bano, E. d. (2008). *Creativity workout: 62 exercises to unlock your most creative ideas.* Ulysses Press.

Bano, E. d. (2009). *Lateral Thinking.* e-Penguin.

Bono, E. d. (2005). *Thinking course (Revised Edition).* Bernes and Nobel

Chopra, R. (n.d.). *Logical Critical Analytical Reasoning.* Galgoba Publications Pvt Ltd.

Eiffert, S. D. (1999). *Cross-train your brain: a mental fitness program for maximizing creativity and achieving success.* Amacom.

Kahneman, D. (2015). *Thinking fast and slow.* New York: Farrar, Straus and Giroux.

Scott, J. W. (2016). *Critical Thinking: Proven strategies for improving your decision making skills, retaining information longer and analyzing situations with simple logic ---- Logical thinking and critical thinking skills.* New Familiar Publishing.

Updated: January 2018

Year 3: Semester I

IST303: Statistical Inference

Module Code & Title: IST303 Statistical Inference
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

The module will enable students to learn different techniques of estimation and its properties. The module also enables students to understand the problems related to point and confidence interval

estimation and testing of hypothesis using R along with inequalities and theorems related to inference.

Learning Outcomes
On completion of the module, the students will be able to:

1. Implement the basic concepts of various properties of estimators.
2. Use the various inequalities to find the lower bound on the variance of estimators.
3. Transform an estimator using the Rao–Blackwell theorem to make a better estimator
4. Test the hypothesis using various tests and lemma.
5. Compute the confidence interval of estimated parameters.
6. Develop robust model with proper handling of outliers in the data
7. Apply the knowledge of Bayesian techniques for getting posterior estimates.
8. Execute randomized and non-randomized tests where one can view how to make a decision in hypothesis testing.
9. Emphasize statistical thinking in decision theory.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach
A. **Assignment: (10%)**
A written assignment will be given in a semester. In written assignments, a set of problems/Theorems (not over 15) covering first four units will be given to the students, which are to be solved by the students independently. The submission of assignment would be two weeks after the assigned date. The assignment will be assessed based on following criteria:

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

B. **Laboratory: The portion of final mark: (15%)**
The laboratory assessment will be carried out as follows:

- **Laboratory report -5%**

  Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

  Objective - 1 mark
  Method description - 2 marks
  Results - 1 mark
  Interpretation/ conclusion - 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam -10%**

A laboratory exam for the duration of 2 hour will be conducted towards the end of a semester after the last day of regular teaching covering all the subject matter.

C. **Mid-Semester Examination: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 40 marks and 20% of the scores will be taken as final score.

D. **Semester-end Examination: (60%)**

Semester end Examination for the duration of three hours will be for 60 marks. All the units of the subject matter will be included for the examination

Overview of Assessment Approaches

Areas of assignments	Approach	Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Laboratory Report	10	5%
	Laboratory Exam	1	10%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	60%

Pre-requisite: PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Estimators and its Properties

1.1 Notion of a parameter
1.2 Parameter space
1.3 General problem of estimation
1.4 Point and interval estimation
1.5 Frechet-Cramer-Rao inequality
1.6 Rao-Blackwell theorem
1.7 Basu's theorem.
1.8 Properties of estimators:
1.8.1 Unbiasedness
1.8.2 Consistency
1.8.3 efficiency and
1.8.4 sufficiency

Unit II: Methods of estimation

2.1 Maximum likelihood
2.2 Ordinary least squares
2.3 minimum χ^2
2.4 minimum distance

2.5 moments
2.6 Robust estimation and robust tests.
2.7 Asymptotic techniques.
2.8 Kernel method for univariate data: Rosenblatt's naïve estimator.
2.9 Consistency of general Kernel estimators, MSE and IMSE.
2.10 Concepts of consistency and asymptotic normality (CAN).
2.11 Cramer-Huzurbazar theorem, method of scoring.
2.12 Robust estimation and tests
2.13 Asymptotic techniques
2.14 Estimation of density function
2.15 Conditional inference

Unit III: Hypothesis Testing

3.1 Randomized and non-randomized tests
3.2 Neyman-Pearson lemma
3.3 Consistency and relative efficiency of tests
3.4 MP test and region
3.5 Power function
3.6 Uniformly most powerful tests and their constructions
3.7 Unbiased tests
3.8 Likelihood ratio tests
3.9 Confidence-interval estimation
3.10 Sequential analysis
3.11 Sequential probability ratio test
3.12 Elements of decision theory and Bayesian inference

Unit IV: Statistical Models for advanced inference

4.1 Detection and handling of outliers in statistical data.
4.2 Loglinear models.
4.3 Saturated models.
4.4 Hierarchical models.
4.5 Analysis of multi - dimensional contingency tables.

Unit V: Statistical Decision Problem

5.1 Decision problem and 2-person game
5.2 Non-randomized decision rules
5.3 Mixed and randomized decision rules
5.4 Decision problem for finite parameter space
5.5 Test of simple hypothesis against a simple alternative from decision theoretic view point.

Unit VI: Bayesian Estimations

6.1 Bayes theorem and computation of posterior distribution
6.2 Bayesian point estimation as a prediction problem from posterior distribution
6.3 Bayes estimators for absolute loss function, squared loss function, 0-1 loss function
6.4 Evaluation of estimates in terms of the posterior risk.
6.5 Bayesian interval estimation
6.6 Bayesian testing of hypothesis
6.7 Bayes factor for various types of testing hypothesis problem depending upon whether the null hypothesis and the alternative hypothesis are simple or composite
6.8 Bayesian prediction problem.

List of Laboratory Sessions

1. Verify the properties of the estimator such unbiasness, consistency, efficiency, and sufficiency
2. Compute the point and interval estimates
3. Compute and compare the estimates using different method of estimation
4. Test the hypothesis using data and construct the confidence intervals
5. Perform the sequential analysis in the data and apply the sequential probability test
6. Identification of outliers in the statistical data
7. Building the model from advance inference methods

Reading Lists

Essential Reading

Casela, G., and Berger, R. L. (2017). *Statistical Inference*, Duxbury Thompson Learning, New Delhi.

Christensen, R. (2013). *Log Linear Models*, Springer, New Delhi.

Conover, W. J. (2007). *Practical Non-parametric Statistics*, John Wiley, New Delhi.

Hogg, R. V., and Craig, T. T. (2019). *Introduction to Mathematical Statistics*, Prentice-Hall, New Delhi.

Mood, A. M. Graybill, F. A., and Boes, D. C. (2017). *Introduction to Theory of Statistics*, Cambridge University Press, New Delhi.

Additional Reading

Box, G. E. P., and Tiao, G. C. (2011). *Bayesian Inference in Statistical Analysis*, Addison Wesely, New Delhi.

Dudewicz, E. J., and Mishra, S. N. (1988). *Modern Mathematical Statistics*. John Wiley, New Delhi.

Rao, C. R. (2001). *Linear Statistical Inference and its Applications*, John Wiley, New Delhi.

Rohatgi, V. K., and Saleh, A. K. Md. E. (2005). *An Introduction to Probability and Statistics*, John Wiley, New Delhi.

Wald, A. (2013). *Sequential Analysis*, Dover Publications, New Delhi.

Date: March, 2022

IST302: Regression Analysis

Module Code & Title: IST302 Regression Analysis
Programme : BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective

In this module students will learn how to derive multiple linear regression models, how to use R software to implement them, and what assumptions underlie the models. Students will also learn how to test whether their data meets those assumptions, what can be done when those assumptions are not met, and strategies to build and understand useful models.

Learning Outcomes

On completion of the module, students will be able to:

1. Calculate both simple and multiple regression models.
2. Visualize univariable linear regression model fits.
3. Implement and infer Ordinary Least Square (OLS) regression using R.
4. Compare linear and nonlinear regression models.
5. Assess parameter estimates of linear models using Gauss-Markoff's theorem.
6. Explain the concept of a best linear unbiased estimator (BLUE).
7. Implement Polynomial regression for data fitting problems.
8. Test homoscedasticity and normality of residuals.
9. Execute the regression diagnostics to non-normal errors, non-constant error variances, correlated observations and nonlinearity of the model.
10. Carry out variable selection and assess model accuracy.
11. Decipher output from R software package.

Learning and Teaching Approaches

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	60
	Laboratory sessions	1	
Independent Study	Written assignment	1	60
	Self-study	3	
Total			120

Assessment Approach

A. Assignment: (10%)

The assignment will be given during the first half of the semester. The assignment will comprise of problem-solving based on some questions provided to them. Assignments will be assessed using following criteria:

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

B. Laboratory sessions (15%):

The lab assessment will be carried out as follows:

Laboratory report - **5%**

Students will submit a weekly record of the lab session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

Laboratory Exam - **10%**
A lab exam for the duration of 2 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. Data Analysis Project (10%):
Students will be divided into groups of 2-5 members depending upon the cohort. Each group will either be provided a data set along with the description of the data and variables, or choose its own dataset after review and approval from the tutor. The group members will collaborate and work together to develop research and analytical plans, conduct analyses and computation, explain and present results in the class. They will be assessed using the following marking criteria:

Objective	- 2 marks
Materials and methods	- 3marks
Results and Discussion	- 3 marks
Conclusion	- 2 marks

D. Mid-Semester Examination (15%)
Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 40 marks and 20% of the scores will be taken as final score.

E. Semester-end Examination (50%)

Semester end Examination for the duration of three hours will be for 60 marks. All the units of the subject matter will be included for the examination

Overview of Assessment Approaches

Areas of assessments	Approach	Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Lab Report	10	5%
	Lab Exam	1	10%
C. Data Analysis Project		1	10%
D. Mid-Semester Examination		1	15%
E. Semester-end Examination		1	50%

Pre-requisites: DTS103 Probability Distribution I

Subject Matter
Unit I: Linear regression with one regressor

1.1 Simple linear regression
  1.1.1 Definition
  1.1.2 Assumptions of simple linear regression
1.2 Estimating the coefficient of the linear regression model
  1.2.1 The Ordinary least square method
  1.2.2 Restricted least squares: special cases of one- and two-way classifications.
1.3 Measures of fit
  1.3.1 The coefficient of determination
  1.3.2 The standard error of the regression
  1.3.3 Application to the test score data
1.4 The least square assumptions
1.5 The sampling distribution of the OLS estimator
1.6 Hypothesis tests and confidence Interval
  1.6.1 Testing two-sided hypotheses concerning the slope coefficient
  1.6.2 Confidence interval for regression coefficients
1.7 Using the t-statistic in regression when the sample size is small
1.8 R Regression when X is a binary variable
  1.8.1 The Gauss-Markov theorem (BLUE)
  1.8.2 Aitken's transformation

Unit II: Regression Model with multiple regressor

2.1 Multiple regression model
2.2 Omitted variable bias
2.3 OLS assumptions in multiple regression
2.4 The measure of fit in multiple regression
2.5 The distribution of the OLS estimator
2.6 Hypothesis testing and confidence interval
  2.6.1 Hypothesis tests and confidence intervals for a single coefficient
  2.6.2 Joint hypothesis testing using the F-statistic
  2.6.3 Confidence sets for multiple coefficients
2.7 Model specification
2.8 Assessing studies based on multiple regression
  2.8.1 Internal and external validity
  2.8.2 Threats to internal validity
  2.8.3 Internal and external validity when the regression is used for forecasting
  2.8.4 Diagnostics
2.9 Multicollinearity, influential observations
  2.9.1 Problems of multicollinearity
  2.9.2 Methods of detecting multicollinearity
  2.9.3 Ridge regression as a remedial for multicollinearity
2.10 Selection of independent variables
  2.10.1 Cross-Validation
  2.10.2 Stepwise variable regression
  2.10.3 selection of variables with ridge regression

Unit III: Nonlinear Regression functions

3.1 A general strategy for modelling nonlinear regression functions
3.2 Nonlinear functions of a single independent variable
  3.2.1 Polynomials
  3.2.2 Logarithms

3.3 Interaction between independent variables
- 3.3.1 Interactions between two binary variables.
- 3.3.2 Interactions between a binary and a continuous variable.
- 3.3.3 Interactions between two continuous variables.

Unit IV: Special Types of Regression

4.1 Regression with panel data
- 4.1.1 Panel Data
- 4.1.2 Panel data with two time period: before and after comparison
- 4.1.3 Fixed effects regression
- 4.1.4 Regression with time fixed effects
- 4.1.5 The fixed effect regression assumptions and standard error for fixed effect
- 4.1.6 Random effects model
- 4.1.7 Mixed effects model

4.2 Regression with a Binary Dependent variable
- 4.2.1 Binary variable and linear probability model
- 4.2.2 Probit and Logit regression
- 4.2.3 Estimation and Inference in the Logit and Probit model

4.3 Instrumental Variable regression
- 4.3.1 The Instrumental variables with a single regression and a single instrument
- 4.3.2 The general instrumental variable regression
- 4.3.3 Checking instrument validity

List of Laboratory Sessions

1. Testing hypothesis in linear models
2. Analysis of variance and Analysis of covariance
3. Fitting Polynomial regression
4. Lab session on Indicator variable technique, Regression with ordinal data, Non-linear regression models
5. Testing the various regression diagnostics
6. Multicollinearity, Ridge regression, principal component regression and robust regression

Reading List

Essential Reading

Bapat, R. B. (2012). *Linear Algebra and Linear Models*, Springer-Verlag, New Delhi.

Barnett, V., and Lewis, T. (1998). *Outliers in Statistical Data*, John Wiley, New Delhi.

Belsley, D. A., Kuh, E., and Welsch, R. E. (2004). *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*, John Wiley, New Delhi.

Draper, N. R., and Smith, H. (1998). *Applied Regression Analysis*, John Wiley, New Delhi.

Kleinbaum, D. G., and Kupper, L. L. (2014). *Applied Regression analysis and other Multivariate Methods*, Duxbury Press, Massachusetts, USA.

Additional Reading

Graybill, F. A. (2000). *Theory and Application of the Linear Model*, Duxbury, North Scituate, USA.

Joshi, D. D. (1987). *Linear Estimation and Design of Experiments*, Wiley Eastern, New Delhi.

Montgomery, D. C., Peck, E., and Vining, G. (2012*). Introduction to Linear Regression Analysis*, John Wiley, New Delhi.

McCullagh, P., and Nelder, J.A. (1989). *Generalized Linear Models*, Chapman and Hall, New Delhi.

Rao, C. R. (2001). *Linear Statistical Inference and Its Applications*, Wiley Eastern, New Delhi.
Searle, S. R., and Gruber, H.J. (2016). *Linear Models*, John Wiley, New Delhi.
Searle, S. R. Casella, G. McCulloch, C.E. (1998). *Variance Components*, John Wiley, New Delhi.
Scheffé, H. (1999). *The Analysis of Variance*, John Wiley, New Delhi.

Date: December, 2021

IST304: Nonparametric and Sequential Methods

Module Code & Title: IST304 Nonparametric and Sequential Methods
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
The module will expose students to the essential ideas of nonparametric and sequential statistical methods of data analysis using R. The students will also develop inferential procedures that are valid under a wide range of shapes for the population distribution and sequential sampling.

Learning Outcomes
On completion of the module, students will be able to:
1. Apply nonparametric statistical techniques using R.
2. Explain the basic properties of nonparametric statistical techniques.
3. Demonstrate nonparametric statistical techniques for one sample.
4. Devise nonparametric statistical techniques for independent K samples.
5. Devise nonparametric statistical techniques for dependent K samples.
6. Derive key theoretical properties of nonparametric estimators, such as the form of the estimators and their asymptotic mean squared error.
7. Apply non-parametric methods in practice to solve real-world problem.
8. Compare efficiency of two group decision making units

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (10%)**
One assignment will be given during the first half of the semester. The assignment will comprise of problem-solving (minimum 15 and maximum 20 questions covering at least 40% of subject matter) which are to be solved by students independently. The assignment will be assessed based on following criteria:
- Correctness of the solutions: 40%

- Logical flow in the process: 20%
- Uniqueness of the solution: 20%
- Use of appropriate terms and symbols: 20%

The final marks will be converted out of 10%.

B. **Laboratory: (30%)**

The Lab assessment will be carried out as follows:

- **Laboratory Assignment – 10%**

In a semester a lab assignment will be assigned for students to do it independently. The module tutor will provide the data on which they will apply the statistical data analysis techniques learned in the lab classes and generate a report with 500–1000word limit. The report will be assessed based on the following criteria:

- Abstract 2%
- Diagrammatic/graphical representation 2%
- Identification and calculation of necessary descriptive 3%
- Interpretation of the descriptive and inferential statistics 2%
- Structure of report 1%

- **Laboratory report – 5%**

Students will submit a weekly record of the lab session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam – 15%**

A lab exam for the duration of 3 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: The portion of final mark: (10%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 50 marks and 10% of the scores will be taken as final score.

D. **Semester-end Examination: Portion of Final Mark: (50%)**

Semester end Examination for the duration of two and half hours will be for 50 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Lab	Lab Assignment	1	10%
	Lab Report	10	5%
	Lab Exam	1	15%
C. Mid-Semester Examination		1	10%

D. Semester-end Examination	1	50%

Prerequisites: PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Nonparametric Method

1.1 Dichotomous Data: Binomial Tests
1.2 One-Sample Location Problems
1.2.1 Location functionals
1.2.2 Sign Rank Test: Invariance and optimality, linear and power, relative efficiency
1.2.3 Sign Test
1.2.4 Permutation tests
1.2.5 one-sample U-statistics
1.3 Two-Sample Location Problems:
1.3.1 Rank Sum Test
1.3.2 Two-sample U-statistics
1.3.3 Mann-Whitney-Wilcoxon Test
1.4 One-Way Layout and Two-Way Layout
1.4.1 Kruskal-Wallis and Friedman tests
1.4.2 Multiple Comparisons
1.5 Independence Problems: Efron's Bootstrap
1.6 Linear rank Statistics
1.7 Chi-square test
1.8 Friedman test
1.9 Spearman's rank-order coefficient test
1.9.1 Run test
1.9.2 Tests for independence
1.9.3 Kolmogorov-Smirnov goodness of fit test
1.9.4 Concepts of asymptotic relative efficiency of tests

Unit II: Nonparametric estimation

2.1 Histogram
2.2 frequency polygon
2.3 Smoothers and Kernels
2.4 Nonparametric density estimation
2.5 point estimation and confidence interval
2.6 Estimation of location and scale parameters
2.7 Estimators associated with distribution free test statistics
2.8 Exact small-sample and asymptotic properties of the Hodges-Lehmann location estimators

Unit III: Data Envelopment Analysis (DEA)

3.1 Statistical Foundation for DEA
3.2 Ratio method
3.3 Graphical Analysis
3.4 Efficiency Comparison of Two Groups of Decision-Making Units (DMU)
3.5 Tests of Returns to Scale
3.6 Tests of Allocative Efficiency
3.7 Tests of Input Separability

Unit IV: Sequential Analysis

4.1 Sequential Probability Ratio Test (SPRT)
4.2 Wald's SPRT
4.3 Truncated Sequential Probability Ratio Test (TSPRT)
4.4 Average Sample Number (ASN) functions
4.5 Operating Characteristics function
4.6 Stein's two stage fixed length confidence interval
4.7 Illustrations with Binomial and Normal distributions
4.8 Sequential estimation, illustration with examples
4.9 Testing Multiple Hypothesis

List of Laboratory Sessions

1. Test for randomness based on total number of runs
2. Kolmogrov Smirnov test for one sample
3. Sign test:
   3.1 one sample two samples
   3.2 large samples.
4. Mann-Whitney U-test
5. Wilcoxon signed rank test-one sample and two samples.
6. Bootstrap and Jackknife calculation
7. Using DAE, numerically measure the relative efficiency.
8. Conduct the sequential probability ratio test

Reading List

Essential Reading

Lehmann, E. L., & D'Abrera, H. J. (2006). *Nonparametrics: statistical methods based on ranks*. Holden-Day.

Wasserman, L. (2006). *All of nonparametric statistics*. Springer Science & Business Media.

Ray, S. C. (2004). *Data envelopment analysis: theory and techniques for economics and operations research*. Cambridge university press.

Additional Reading

Hollander, M., Wolfe, D. A., & Chicken, E. (2013). *Nonparametric statistical methods* (Vol. 751). John Wiley & Sons

Randles, R. H., & Wolfe, D. A. (1991). *Introduction to the theory of nonparametric statistics* (No. BOOK). John Wiley.

Wald, A. (2004). *Sequential analysis*. Courier Corporation.

Date: December, 2021

RMS301: Research Methods

Module Code and Title: RSM301 Research Methods
Programme: BSc in Environmental Science
Credit Value: 12
Module Tutor: Pema Wangdi

General Objective:

This module will introduce students to basic research methods. It will provide an overview of quantitative and qualitative research methods. The module will teach design issues, finding and

assessing research papers. It will provide skills and understanding of research process to write the research proposal.

Learning Outcomes:

On completion of the module, students will be able to:

1. Discuss principles of quantitative and qualitative research
2. Identify criteria involved in choosing an appropriate design
3. Distinguish between research purpose, research question and objective
4. Compare different data sources for its strengths and weakness
5. Distinguish between various sampling methods
6. Find and assess research articles
7. Identify different elements in a research article
8. Identify types of literature review
9. Use reference manager tool in research process
10. Apply ethical principles in a research proposal and literature review
11. Understand how to organize a literature review
12. Develop a preliminary research proposal

Learning and Teaching Approach

The module will use the following learning and teaching approach:

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	4	60
Independent study	Written assignment	3	45
	Self-study	1	15
Total			**120**

Assessment Approach

Assessments will be carried out on a continuous basis through the following assignments:

A. Research Article Review (15%):

Each student will select two research articles from journals identified by the tutor for review. The review should summarise and evaluate the elements of a research paper such as research problem, purpose, objectives, key variables, design, instrument, data source, scope and the main ideas of the paper. Each review should be presented within 500 words, which will contribute to 7.5% of the assessment weighting, evaluated basedhe following criteria.

Criteria	85 - 100%	71 - 84%	60 - 70%	<60%	Marks Assigned (%)
Content of Review	In depth analysis of the content (all major points discussed). Excellent summary. Communicates the key ideas/ themes/ findings with a high degree of clarity and insight. Engaging introduction and conclusion, both indicate the overall focus of the paper	Comprehensive analysis of the content (most of the major points discussed). Adequate summary. Communicates the key ideas/findings with considerable clarity, but lacks insight. Engaging introduction and conclusion, paper focus inconsistently supported.	Minimal analysis of the content (some of the major points discussed). Basic summary. Communicates the key ideas/themes/findings with little clarity or insight. Introduction and conclusion do not indicate the overall focus of the paper.	No content (missed all major points of the content). Incomplete summary. Key ideas/findings are not communicated clearly and/or missed in analysis. There is no clear introduction or conclusion.	/40
Reflection	Demonstrates thorough understanding of the article by listing all key findings and reflecting upon their implications.	Demonstrates considerable understanding of the article by listing all of the key findings.	Demonstrates some understanding of the article by listing some of the key findings but documentation is lacking in completeness.	Demonstrates little understanding of the article with few or no key findings reported.	/30
Organization & Development of Ideas	Logical development of ideas through well- developed paragraphs, good use of transitions.	Logical organization, paragraph development not perfected.	Logical organization, paragraphs not fully developed.	No evidence of structure or organization.	/15
Mechanics	Meets length requirement. 1-2 grammatical errors. 1-2 punctuation errors. APA Guidelines are meticulously followed. Adheres to Font/Spacing Guidelines.	Length requirement is met with adequate content 3-4 grammatical errors. 3-4 punctuation errors. Adheres consistently to APA guidelines, however, one error present.	Length requirement is not met; minimal content 5-6 grammatical errors 5-6 punctuation errors Demonstrates little ability to adhere to APA guidelines, more than two errors present. Adheres to neither Font nor Spacing Guidelines.	Length requirement is not met; poor content Numerous grammatical errors (distracting) Numerous punctuation errors Neither style is used Does not adhere to	/15

		Adheres to either Font or Spacing Guidelines, but not both.		Font/Spacing Guidelines	

B. Literature Review: Portion of the final marks: 20%

Each student will conduct a brief literature review on the chosen topic of interest. The review could add on to the “Literature Review” section of the research proposal assignment (Assessment C). It must provide an overview of the topic, identify research problems and question to address. The literature review should be of 1500 words and it will be assessed based on the following criteria:

Criteria	80 - 100%	60 - 79%	<60%	Marks Assigned (%)
Title and Structured Abstract	The abstract has appropriate sections and concisely reflects the content of the review.	The abstract reflects the content of the review, but is unclear or could be more concise.	Structured abstract not included.	/5
Introduction	Provides excellent background information, including relevance of the review. Research question and purpose is clearly articulated. Context and rationale for the review is clearly described.	Research question is articulated, but relevance and context are not adequately described.	Relevance of the review is not explained. Research question is poorly articulated or absent.	/15
Methods	Search methods are appropriate for the topic and clearly described. Search strategy includes appropriate search terms and relevant synonyms. Inclusion/exclusion criteria are articulated with sound rationale.	Search methods are mostly appropriate for the topic. Description of search methods missing some details. Search includes most relevant synonyms. Article inclusion/exclusion criteria adequately articulated.	Description of search methods inadequate or absent. Search is inadequate (missing key databases or search terms). Article inclusion/exclusion criteria not listed or unclear.	/10
Results/ Discussion	Synthesizes and analyzes the literature accurately. Focuses on central ideas, and critically evaluates sources & perspectives. Identifies gaps & controversies, as well as study limitations if relevant.	Summarizes the literature, but misses some key points. Does not adequately evaluate sources and perspectives. Does not relate findings to the research question.	Lists findings, instead of synthesizing literature. Provides summary instead of critique. Too few sources discussed. Sources are inappropriate for the research question.	/35
Conclusion	Clearly summarizes literature review results. Identifies implications for practice and/or research. Provides a compelling argument/ conclusion that is appropriately qualified (given study limitations).	Summarizes literature review results. Conclusion is weak or unsupported by evidence.	Lacks a final summary / conclusion. Implications for research or practice not articulated.	/15
Referencing	All sources are correctly cited in an existing bibliographic style (APA).	A few minor errors in citation formatting.	Cittation format inconsistent. Citations incomplete or missing.	/10

Quality of Writing	Prose is clear. Thoughts are well organized. Style and vocabulary are appropriate for a research paper. No typos or grammatical errors.	Writing is acceptable, but could be more polished. Style is too informal for a research paper. Inadequate proofreading.	Poorly written. Frequent grammatical or spelling errors.	/10

C. Research Proposal Assignment: Portion of the final marks 25%

Each student will write a research proposal on the chosen topic. The research proposal should include introduction (purpose, problem statement and objectives), literature review, and methods. The research proposal should not be less than 2000 words. It will be assessed based on the following criteria:

Criteria	<60%	60 - 79%	80 - 100%	Marks Assigned (%)
Introductory Matters: Title and Abstract	Title or abstract lacks relevance or fails to offer appropriate details about the educational issue, variables, context, or methods of the project.	Title and abstract are relevant, offering details about the research project.	Title and abstract are informative, succinct, and offer specific details about the educational issue, variables, context, and proposed methods of the study.	/5
Introduction: Problem, Significance, & Purpose of the Study	Research issue is identified, but statement is too broad or fails to establish the importance of the problem. The research purpose, questions, hypotheses, definitions or variables and controls are poorly formed, ambiguous, or not logically connected to the description of the problem. Unclear connections to the literature.	Identifies a relevant research issue. Research questions are succinctly stated, connected to the research issue, and supported by the literature. Variables and controls have been identified and described. Connections are established with the literature.	Presents a significant research problem related to the chemical sciences. Articulates clear, reasonable research questions given the purpose, design, and methods of the project. All variables and controls have been appropriately defined. Proposals are clearly supported from the research and theoretical literature. All elements are mutually supportive.	/15
Literature Review	A key component was not connected to the research literature. Selected literature was from unreliable sources. Literary supports were vague or ambiguous.	Key research components were connected to relevant, reliable theoretical and research literature.	Narrative integrates critical and logical details from the peer-reviewed theoretical and research literature. Each key research component is grounded to the literature. Attention is given to different perspectives, threats to validity, and opinion vs. evidence.	/15

Methods: Research Design	The purpose, questions, and design are mutually supportive and coherent. Attention has been given to eliminating alternative explanations and controlling extraneous variables. Appropriate and important limitations and assumptions have been clearly stated.	The research design has been identified and described in sufficiently detailed terms. Some limitations and assumptions have been identified.	The research design is confusing or incomplete given the research questions and strategy. Important limitations and assumptions have not been identified.	/20
Methods: Instruments	Descriptions of instruments and techniques included. Evidence of the validity and reliability was presented.	Instruments and observation protocols were identified by name and described.	Description of the instruments and techniques were confusing, incomplete, or lacked relevance to the research questions and variables.	/15
Methods: Procedures	Procedures were thorough, coherent, and powerful for generating valid and reliable data. Procedures were replicable.	Procedures for project were identified and described in an appropriate fashion.	Procedures were confusing, incomplete, or lacked relevance to purpose, research questions, or sampling strategy.	/20
Methods: Data Analysis	Analytical methods were sufficiently specific, clear, and appropriate for the research questions.	Both descriptive and statistical methods were identified. Level of significance was stated.	Descriptive or statistical methods were confusing, incomplete or lacked relevance to the research questions, data, or research design.	/10

D. Semester-end Examination: Portion of the final marks 40%

Semester-end examination will cover the subject matter taught in the class. The exam will assess students' knowledge of the content using Blooms Taxonomy. A common end-semester examination will be conducted for all programmes offering the module.

Overview of the assessment approaches and weighting

Areas of assignments	Quantity	Weighting
A. Research Article Review	2	15
B. Literature Review	1	20
C. Research Proposal Assignment	1	25
D. Semester-end Examination	1	40

Pre-requisites: None

Subject Matter:

Unit I: Introduction

1.1. Meaning of Research

1.2. Objectives of Research

1.3. Motivation of Research
1.4. Types of Research: Descriptive, Analytical, Applied, Fundamental, Qualitative and Quantitative, Conceptual and Empirical Research
1.5. Research Approaches
1.6. Significance of Research
1.7. Research method vs. Methodology
1.8. Research and Scientific Method
1.9. Importance of Knowing How Research is Done
1.10. Research Process
1.11. Criteria of Good Research

Unit II: Research Problem

2.1. What is Research Problem
2.2. Selecting the Research Problem
2.3. Necessity of Selecting the Problem
2.4. Technique Involved in Defining a Problem

Unit III: Review of Literature

3.1. Concept and need for review of literature
3.2. Locating resources for literature review
3.3. Organising and cite literature using reference manager (Zotero)
3.4. Formulation research questions and hypotheses
3.5. Types of research hypothesis

Unit IV: Research Design

4.1. Meaning of Research Design
4.2. Need for Research Design
4.3. Features of a Good Design
4.4. Important Concepts Relating to Research Design
4.5. Differences quantitative and qualitative research designs
4.6. Quantitative research designs
  4.6.1. Basic principles of experimental designs (replication, randomisation and control)
  4.6.2. Important experimental designs (before-and-after without control, after-only with control, before- and after with control)
  4.6.3. Quasi-experimental designs
  4.6.4. Cross-sectional and longitudinal study designs
  4.6.5. Correlational designs
4.7. Qualitative study design - case study, ethnography, phenomenology, grounded theory

Unit V: Measurement and Sampling

5.1. Measurement Process: Conceptualization and Operationalization
5.2. Reliability and validity
5.3. Levels of measurement
5.4. Designing instruments
5.5. Types of Sampling Design: Probabilistic and non-probabilistic sampling

Unit VI: Ethics and Data Collection

6.1. Ethical principles in research
6.2. Secondary and primary data

6.3. Qualitative data collection: Individual interviews, focus groups, observations
6.4. Quantitative data collection: Survey, lab and data logger

Reading list:

Essential reading:

Bhattacherjee, A. (2012) *Social science research: Principles, methods, and practices*. Published under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. Open access book available at: https://open.umn.edu/opentextbooks/textbooks?term=research&commit=Go

Bryman, A. (2016). *Social research methods*. Oxford university press.

Jhangiani,R. S., I-Chant A. Chiang, I. A., Cuttler, C & Leighton, D. C (2019). *Research methods in psychology*. Licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. Open access book available at: https://open.umn.edu/opentextbooks/textbooks?term=research&commit=Go

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Kumar, R. (2019). *Research methodology: A step-by-step guide for beginners*. Sage Publications Limited.

Additional reading:

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Ghosh, B. N. (2007). Scientific Method and Social Research (Revised edition). New Delhi: Sterling Publishers Pvt. Ltd.

Grix, J. (2002). The foundations of Research. Palgrave Foundations. New York. (accession no.001.4 GRI)

Patten, M. L., & Newhart, M. (2017). *Understanding research methods: An overview of the essentials*. Taylor & Francis.

Punch, K. F. (2005). Introduction to Social research: Qualitative and Quantitative Approaches. London: Sage Publication.

Wolf, H. K. and Pant, P. R. (2002). Social Science Research and Thesis Writing. Kathmandu: Buddha Academic

Date: November 2020

EDP101: Entrepreneurship

Module Code and Title: EDP101 Entrepreneurship
Programme : University-wide module
Credit Value: 12
Module Tutors: Ugyen Lhendup, Dawa Drakpa, Tenzin Rabgay, Kinley Yangden
Module Coordinator: Dawa Drakpa

General objective

The module will enable students to kindle the spirit of enterprise in themselves, evaluate and develop their skills, and motivate them to consider entrepreneurship as a career option. The module intends to enable students to assess the Bhutanese labor market, economy, and equip them with ability to identify business ideas, spot business opportunities, develop business model and business plan/proposal.

Learning outcomes

On successful completion of the module, students should be able to:

1. Explain the Bhutanese labor market and the role of entrepreneurship
2. map out the Bhutanese entrepreneurship ecosystem
3. explain policies related to entrepreneurship in Bhutan
4. evaluate entrepreneurial competencies
5. develop entrepreneurial competencies
6. identify solution driven business ideas
7. evaluate business opportunities
8. use value chain analysis to generate business ideas
9. apply business model to develop business plan
10. develop a feasible business plan
11. pitch and present business plans

Teaching and learning approaches

Approach	**Hours per week**	**Total credit hours**
Lectures	2	30
Class discussions, exercises, presentations, role plays, seminar, entrepreneur talk, debate and case studies	2	30
Independent study and library research, assignments, project work	4	60
Total		**120**

Assessment Approach

A. Case writing/analysis: Portion of Final Marks-10%

Each student will be required to write a case about an entrepreneur and the enterprise in the locality (maximum 1200 words). The case must document the entrepreneurial journey from idea to starting business to challenges, opportunities and way forward. The students must produce documentary evidence such as interview recordings, minutes, and images to support their work.

Criteria:

3% organization of ideas
5% content
2% evidence and validity

OR

Each student will be required to analyze a case and write a case analysis report of maximum 1200 words.

Criteria:

2% organization of ideas
6% analysis (identification of issues, analysis of decision alternatives, recommendations/suggestions)
2% referencing

B. Group Work: Business Opportunity identification and selection: Portion of Final Marks-10%

Students in groups of 3-5 members or individually will engage in ideation exercise and generate ideas as well as select a business opportunity. The students will be required to submit idea evaluation report of maximum 1200 words. Criteria:

2% Environmental scanning
3% generating ideas
3% evaluation of ideas
1% selection of ideas
1% Evidence

C. Group Work: Business Model Development Portion of Final Marks-10%

Students in groups of 3-5 members will develop business model for the opportunity selected. Criteria:

7% Business Model and explanation of building blocks
3% Business Model Canvas

D. Project: Business Plan Development (2 parts and final version): Portion of Final Marks50%

Students will work in groups of five to develop a business plan specific for the Bhutanese market. There will also be a group presentation (approximately 10-15 minutes) that includes slides.

Written report (30%):

10% Part A (In-depth overview, market analysis and marketing plan):
10% Part B (Production and operations, Human Resource and financial plan): 10%
Part C Final draft:

1% Executive summary
1% Project Description
1% Market analysis
1% marketing plan
1% operation plan
1% human resources plan
1% financial plan
1% referencing
1% appendices
1% general structure
10% Individually assessed process score (contribution to the group output part A 3%, Part B 3% and Part C 4%)

Presentation (10%):

Group presentation mark (6%)

Cohesiveness: 2%
Organization: 1%
Level of professional delivery: 2%

Questioning & Answering (2%)

4% Individual presentation mark

Clarity: 1%
Conciseness: 1%

Content: 1%
Tone: 1%

E. Semester-End Examination: Portion of Final Marks-20%
The module will have a semester-end examination for 1 hour covering the entire syllabus. Cases will also be used to test the levels of knowledge.

Areas of assignments	**Quantity**	**Weighting**
A. Case writing/analysis	1	10%
B. Group Work	2	20%
C. Project: Business Plan Development (2 parts and final report)	3	40%
Business Plan Presentation	1	10%
Total Continuous Assessment (CA)		**80%**
D. **Semester-End Examination (SE)**	1	**20%**
TOTAL		**100%**

Pre-requisites: None

Subject Matter:

UNIT I: Introduction to Entrepreneurship
1.1 Definition and concept of Entrepreneurship
1.2 Types of entrepreneur
1.3 Characteristics of an entrepreneur
1.4 Entrepreneurial functions
1.5 The entrepreneurial method
1.6 Bhutanese entrepreneurship ecosystem (course pack - Entrepreneurship related strategies in Bhutan)
1.7 Role and scope of entrepreneurship in Bhutan

UNIT II: The Entrepreneurial Mind-Set and competencies
2.1 The Entrepreneurial Thinking
2.2 Grassroot Innovations (course pack – include emerging trends/opportunities in Bhutan)
2.3 Problem solving techniques
2.4 Entrepreneurial motivation
2.5 Evaluation of entrepreneurial competencies using GETT/SRQ (course pack should include networking, negotiation, motivation etc)
2.6 Emotional resilience and entrepreneurial discipline

UNIT III: Business Opportunity Identification (BOI) and selection
3.1 Meaning of business opportunity
3.2 BOI process
3.2.1 Environmental scanning
3.2.2 Generating ideas (course pack – include process & techniques of idea generation)
3.2.3 Identifying and evaluating ideas/opportunities
3.2.4 Selecting ideas/opportunities
3.3Value chain analysis and business development

UNIT IV: Business Model
4.1Business model canvas
4.2Sustainable business models

UNIT V: Building up a Business Plan
5.1 Overview
5.1.1 Need and importance of business plan
5.1.2 Audience of business plan
5.1.3 Components of a business plan
5.2 In-depth business overview
5.2.1 Business profile
5.2.2 Business background
5.2.3 Vision
5.2.4 Mission
5.2.5 Objectives
5.2.6 Keys to success and USPs

UNIT VI: Market Analysis
6.1Business environment analysis
6.1.1 SWOT
6.1.2 STEEPLES
6.2 Market research
6.3 Target market
6.4 Target customers
6.5 Demand analysis
6.6 Competitor analysis
6.7 Price determination
6.8 Income and revenue forecasting

UNIT VII: Marketing Plan
7.1 Marketing Mix (including costing)

UNIT VIII: Production and Operations
8.1 Product/Service description
8.2 Production process
8.3 Plant and equipment (including costing)
8.4 Inventory (including costing)
8.5 Administration (including costing)

UNIT IX: Human Resource Management
9.1 A brief introduction to human resources
9.2 Organizational chart
9.3 Owner(s) and CEO
9.4 Required staff
9.5 Recruitment and selection options
9.6 Training programs
9.7 Human resource costing

UNIT X: Financials
10.1 Estimated project cost
10.2 Financing the project

10.3 Capital cost
10.4 Depreciation schedule
10.5 Financing cost: Cost of equity, cost of debt, and weighted average cost of capital, loan amortization schedule.
10.6 Projected cash flow statement
10.7 Projected income statement
10.8 Projected financial position
10.9 Economic Analysis
10.9.1 Break-even analysis
10.9.2 Pay-back period
10.9.3 NPV

Reading List

Essential Reading

Hisrish, R., Peters, M., & Shepherd, D. (2016). *Entrepreneurship* (10th ed.). McGraw Hill Education.

Hsieh,T. (2014). Delivering Happiness: A path to profits, passion and purpose. Grand Central Publishing

Isaacson, W. (2011). Steve Jobs. Simon & Schuster.

Kuratko, D. F. (2016). Entrepreneurship: Theory, process and practice (10th ed.). South Western College Publication.

Mycoskie, B. (2012). Start Something That Matters. Random House Inc.

Additional Reading

Barringer, B.R., & Ireland, R.D. (2015). *Entrepreneurship: Successfully launching new ventures* (5th ed.). Pearson.

Drucker, P.F. (2006). *Innovation and entrepreneurship.* Harper Business.

Hisrish, R., Peters, M., & Shepherd, D. (2016). *Entrepreneurship* (10th ed.). McGraw Hill Education.

Johnson, K.D. (2013). *The entrepreneur mind: 100 essential beliefs, characteristics, and habits of elite entrepreneurs.* Johnson Media Inc.

Kumar, A., (2012). *Entrepreneurship: Creating and leading an entrepreneurial organization*. Pearson (India).

Kuratko, D. F. (2016). *Entrepreneurship: Theory, process and practice* (10th ed.). South Western College Publication.

Osterwalder, A & Pigneur, Y. (2017). *Business Model Generation.* Self-published.

Royal Government of Bhutan. (2007). *Labour and Employment Act of Bhutan.* National Assembly of Bhutan.

Royal Government of Bhutan. (2012). *Cottage Small and Medium Industry policy.* Royal Government of Bhutan.

Royal Government of Bhutan. (2016). *Companies Act of Bhutan.* Natioional Assembly of Bhutan. Retrieved October 24, 2017, from http://www.nab.gov.bt/en/business/acts

Royal Government of Bhutan. (2017). *12th Five-Year Plan.* Royal Government of Bhutan.

Royal Government of Bhutan. (2017). *Economic Development Policy of Bhutan.* Ministry of Economic Affairs.

Royal Government of Bhutan. (n.d.). *BAS for SMEs.* Riyal Government of Bhutan.

Royal Government of Bhutan. (n.d.). *Cottage Small and Medium Industry Development Strategies (2012-2020) n..* Royal Government of Bhuta

Scarborough, N.M. (2014). *Entrepreneurship and effective small business management* (11th ed.). Pearson.
Shankar, R. (n.d.). *Entrepreneurship: Theory and practice* (1st ed.). McGraw Hill Education.

Updated: January 2018

Year 3: Semester II

IST305: Statistical Quality Control
Module Code & Title: IST305 Statistical Quality Control
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
The module will enable students' understanding in quality control terminology, practices, statistics, and troubleshooting for any statistical laboratory. The module will also give students a firm grounding to quickly and easily identify and correct errors in quality control procedures using R.

Learning Outcomes
On completion of the module, students will be able to:
1. Explain the basic concepts of quality control for industrial purposes.
2. Construct various control charts for monitoring the process control.
3. Describe categories of statistical quality control (SQC).
4. Explain the use of descriptive statistics in measuring quality characteristics.
5. Formulate the causes of variation in the process.
6. Describe the use of control charts.
7. Identify the differences between x-bar, R-, p-, and c-charts.
8. Explain the meaning of process capability and the process capability index.
9. Explain the process of acceptance sampling and describe the use of operating characteristic (OC) curves.
10. Describe the challenges inherent in measuring quality in service organizations.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach
A. **Assignment: (10%)**
One assignment will be given to an individual student during the first half of the semester. The assignment will comprise of problem-solving based on some questions (minimum of 10 and

maximum of 15 covering at least 50% of subject matter) provided to them. The given assignment will be assessed using following criteria:

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

B. **Laboratory: (30%)**

The lab assessment will be carried out as follows:

- **Laboratory Assignment (10%)**

One lab assignment worth 10% will be assigned for students to do independently. The module tutor will provide the data on which they will apply the statistical data analysis techniques learned in the lab classes and generate a report. The report will be assessed based on the following criteria:

- Abstract 2%
- Diagrammatic/graphical representation 2%
- Identification and calculation of necessary descriptive 3%
- Interpretation of the descriptive and inferential statistics 2%
- Structure of the report : 1%

- **Laboratory report (5%)**

Students will submit a weekly record of the lab session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam (15%)**

A lab exam for the duration of 3 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: (10%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 50 marks and 10% of the scores will be taken as final score.

D. **Semester-end Examination: Portion of Final Mark: (50%)**

Semester end Examination for the duration of two and half hours will be for 50 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments	Quantity	Weighting
A. Assignment	1	10%

B. Lab	Lab Assignment	1	10%
	Lab Report	10	5%
	Lab Exam	1	15%
C. Mid-Semester Examination		1	10%
D. Semester-end Examination		1	50%

Prerequisite: PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Introduction

1.1 Concept of quality and its management - quality planning
1.2 Quality control and quality improvement
1.3 Concept of variations and its impact
1.4 Relevance of exploratory data analysis
1.5 Run plot and lag plot
1.6 Frequency distribution and other QC tools.

Unit II: Measurement System

2.1 Introduction to measurement system
2.2 Types of measurement
2.3 Measurement validity
2.4 Measurement errors and their estimation

Unit III: Use of Control Chart

3.1 Introduction to control chart
3.2 control chart for variables and attributes:
- 3.2.1 X-MR chart
- 3.2.2 X-R chart
- 3.2.3 X-s chart
- 3.2.4 p-chart
- 3.2.5 np-chart and c-chart
- 3.2.6 u- chart
- 3.2.7 CUSUM chart
- 3.2.8 EWMA chart

3.3 process capability analysis:
- 3.3.1 Capability indices
- 3.3.2 Estimation of capability indices
- 3.3.3 Exact distribution of capability indices
- 3.3.4 Asymptotic distribution of capability indices
- 3.3.5 Tolerance intervals

Unit IV: Acceptance Sampling

4.1 Introduction to acceptance sampling
4.2 Concept of AQL and LTPD
4.3 Producer's risk and consumer's risk
4.4 Single sampling plan and its OC function
4.5 Acceptance rectification plan: acceptance sampling tables
4.6 Concept of double and multiple sampling plans

4.7 Average sample number.

List of Laboratory Sessions

1. Construction and interpretation of statistical control charts: X-bar & R-chart, X-bar, s-chart, np-chart, p-chart, c-chart, & u-chart 2.
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
4. Use a case study to apply the concept of six sigma application in DMAIC: practical application

Reading List

Essential Reading

Leavenworth, R. S., & Grant, E. L. (2000). *Statistical quality control.* Tata McGraw-Hill Education.

Montgomery, D. C. (2007). *Introduction to statistical quality control.* John Wiley & Sons.

Additional Reading

Tebbutt, T. H. Y. (2013). Principles of water quality control. Elsevier.
Besterfield, D. H. (2004). Quality control. Pearson Education India.
Evans, J. R., & Lindsay, W. M. (2002). The management and control of quality (Vol. 5, pp. 115-128). Cincinnati, OH: South-western.

Date: March, 2022

AMT311: Introduction to Operations Research

Module Code & Title: AMT311 Introduction to Operations Research
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective

This module introduces mathematical methods for formulating, solving and providing quantitative data for managerial decision making under the given constraints of resources. It also introduces decision making under deterministic and probabilistic situations. Linear programming models, transportation and assignment models, network models and decision trees will be discussed in detail. The students will also be trained to use TORA, Excel Solver and R to solve optimization problems.

Learning Outcomes

On completion of the module, the students will be able to:

1. Formulate a given real-life optimization problem into a Linear Programming Problem (LPP) with a clear objective function and constraints.

2. Solve a given LPP using appropriate method and interpret the result.
3. Obtain the optimal solution to a given transportation model/ assignment model and estimate the least cost for the model.
4. Draw a network diagram for a given project schedule and find the optimum duration using Critical Path Method (CPM).
5. Solve a network model using Programme Evaluation and Review Technique when the duration of each activity has the most optimistic and most pessimistic completion time.
6. Draw a decision tree for a decision making problem and use expected value criterion to make optimize cost/ profit.
7. Solve an integer programming problem using Branch and Bound algorithm or Cutting-Plane algorithm.
8. Formulate a goal programming and solve it using weights method or preemptive method.
9. Use TORA, Excel Solver and R to solve decision making problems.

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Tutorial	1	
Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Group Assignment: (15%)**

Six problems from the first three units will be given to the students. Groups of three randomly selected students will be formed and each group is expected to solve the problems and submit the solutions. The mark awarded to each group will be the mark for each corresponding member of the group. The following rubric will be used for the evaluation and grading.

Category	Poor (0)	Satisfactory (1)	Good (2)	Very Good (3)	Excellent (4)
Understanding: How clearly the problems are understood and executed.	Shows no understanding of the problems	Shows limited understanding of the problems; may misuse or fail to use mathematical terms, formula/ method/ algorithm and may make major computational errors	Shows understanding of some of the problems; may use partially correct formula/ method/ algorithm and may contain partial computational errors	Shows nearly complete understanding of the problems; uses nearly correct mathematical terminology and notations; uses and executes formula/ method/ algorithm completely and computations are generally correct but	Shows complete understanding of the problems; uses appropriate mathematical terminology and notations; Uses and executes formula/ method/ algorithms completely and correctly leading to authentic result

				may contain minor errors	
Approach: How the problems being solved	Fails to indicate which elements of the problem are appropriate; wrong use of formula/ method/ algorithm; copies part of the problem but without attempting towards a solution	Gives incomplete evidence of a solution process; solution process may be missing; difficult to identify or completely unsystematic	Gives some evidence of a solution process but solution process may be incomplete or somewhat unsystematic	Gives clear evidence of a solution process and solution process is complete or nearly complete and systematic	Reflects an appropriate and systematic strategy for solving the problem and gives clear evidence of a solution process and solution process is complete and systematic
Decision: Procedural changes/ transitions while solving the problems	No reasoning at all	No reasoning is evident from the work or reasoning is incorrect	Partly correct reasoning or correct reasoning used for only part of the problems	Didn't clearly explain the reasons for decisions but work suggests correct reasoning used for only part of the problem	Clearly explained the reasons for the correct decisions made throughout the problems
Result: How authentically the result is obtained and its interpretation	Not solved the problems.	Solved the problem and stopped without the result	Solved the problems, however with wrong result and with its corresponding interpretation	Solved the problem obtaining the result with nearly to its correct interpretation	Solved the problem getting the correct result with its complete and authentic interpretation

B. **Individual Assignment: (15%)**

Five problems from the last three units will be given to the students. They are expected to solve the problems individually and submit the solutions. The evaluation and grading will be based on the following rubric.

Category	**Poor (0)**	**Satisfactory (1)**	**Good (2)**	**Very Good (3)**	**Excellent (4)**
Understanding: How clearly the problems are understood and executed.	Shows no understanding of the problems	Shows limited understanding of the problems; may misuse or fail to use mathematical terms, formula/ method/ algorithm and may make	Shows understanding of some of the problems; may use partially correct formula/ method/ algorithm and may contain	Shows nearly complete understanding of the problems; uses nearly correct mathematical terminology and notations; uses and executes	Shows complete understanding of the problems; uses appropriate mathematical terminology and notations; Uses and executes

		major computational errors	partial computational errors	formula/ method/ algorithm completely and computations are generally correct but may contain minor errors	formula/ method/ algorithms completely and correctly leading to authentic result
Approach: How the problems being solved	Fails to indicate which elements of the problem are appropriate; wrong use of formula/ method/ algorithm; copies part of the problem but without attempting towards a solution	Gives incomplete evidence of a solution process; solution process may be missing; difficult to identify or completely unsystematic	Gives some evidence of a solution process but solution process may be incomplete or somewhat unsystematic	Gives clear evidence of a solution process and solution process is complete or nearly complete and systematic	Reflects an appropriate and systematic strategy for solving the problem and gives clear evidence of a solution process and solution process is complete and systematic
Decision: Procedural changes/ transitions while solving the problems	No reasoning at all	No reasoning is evident from the work or reasoning is incorrect	Partly correct reasoning or correct reasoning used for only part of the problems	Didn't clearly explain the reasons for decisions but work suggests correct reasoning used for only part of the problem	Clearly explained the reasons for the correct decisions made throughout the problems
Result: How authentically the result is obtained and its interpretation	Not solved the problems.	Solved the problem and stopped without the result	Solved the problems, however with wrong result and with its corresponding interpretation	Solved the problem obtaining the result with nearly to its correct interpretation	Solved the problem getting the correct result with its complete and authentic interpretation

C. **Computer Solution to Optimization Problems: (10%)**

Six problems – one from each unit will be given. Students are expected to solve each problems using TORA or Excel Solver or R or Python individually and upload the results in VLE as a PDF file. Grading will be based on the following criteria:

- The choice of package usage 10%
- Sequential usage of functions/ syntaxes and error debugging 40%
- Correctness of the solution 20%
- Creative and innovative display of the work 30%

The mark achieved will be converted out of 10%.

D. **Mid-semester Examination: (15%)**

Mid-semester Examination will be conducted for a duration of two hours of 40 marks, which eventually will be converted out of 15%. The conduction of the examination will be on coverage of at least 60% of the syllabus; at least the first four units of the subject matter should be covered.

E. **Semester-end Examination: (45%)**
Semester end Examination will be conducted for the duration of two and half hours of 50 marks, which eventually will be converted out of 45%. The examination will cover questions from all the units of the subject matter of the module with the format and pattern as per the academic norms. The test blue print and an answer key for grading will also be prepared along with the question paper.

Overview of assessment approaches and weightings:

Areas of assignments	Quantity	Weighting
A. Group Assignment	1	15%
B. Individual Assignment	1	15%
C. Computer Solution to Optimization Problems	1	10%
D. Mid-semester Examination	1	15%
E. Semester-end Examination	1	45%

Pre-requisite: PLT102 Programming in Python**,** PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Linear Programming Problems (LPP)

1.1 Introduction to LPP
1.2 Formulation of LPP
1.3 Types of solutions of LPP
1.4 Solution of LPP:
1.4.1 Graphical Method
1.4.2 Simplex Method
1.4.3 Use of Artificial Variables in simplex method:
1.4.3.1 Charnes' Big M method
1.4.3.2 Two Phase Method
1.5 Infeasible solutions
1.6 Duality in LPP
1.7 Dual Simplex Method
1.8 Degeneracy
1.9 Sensitivity analysis
1.10 Computer solution to LPP with TORA, Excel Solver, R and Python

Unit II: Transportation Problems (TP) and Assignment Problems (AP)

2.1 Introduction to Transportation Problem
2.2 TP as a case of LPP
2.3 Methods to obtain initial basic feasible solution to a TP:
2.3.1 North West Corner Rule
2.3.2 Matrix Minima Method
2.3.3 Vogel's Approximation Method
2.3.4 Solution of the TP by MODI method
2.3.5 Degeneracy in TP

2.3.6 Unbalanced transportation problems and their solutions.
2.4 Introduction to AP
2.5 AP as a complete degenerate form of TP
2.6 Hungarian Method for solving AP
2.7 Unbalanced Assignment Problems and their solutions
2.8 AP with restrictions
2.9 Computer solution to TP and AP using TORA, Excel Solver, R and Python

Unit-III: Network Analysis

3.1 Network representation of a Project Rules for construction of a Network
3.2 Use of Dummy activity
3.3 The critical Path method (CPM) for constructing the time schedule for the project
3.4 Float (or shack) of an activity and event
3.5 Programme Evaluation and Review Technique (PERT)
3.6 Probability considerations in PERT
3.7 Probability of meeting the scheduled time
3.8 PERT Calculation
3.9 Distinctions between CPM and PERT
3.10 Computer solution to network problems using TORA, Excel Solver, R and Python

Unit IV: Decision Analysis

4.1 Decision making under certainty
4.2 Decision making under risk
4.2.1 Decision trees
4.2.2 Expected value criterion
4.2.3 Variations of the expected value criterion
4.3 Decision making under uncertainty

Unit V: Integer Linear Programming (ILP)

5.1 Examples of Integer Linear Programming
5.1.1 Capital budgeting
5.1.2 Self-covering problem
5.1.3 Fixed-charge problem
5.1.4 Either-or and If-then constraints
5.2 Integer programming algorithms
5.2.1 Branch-and-Bound algorithm
5.2.2 Cutting-Plane algorithm
5.2.3 Computational considerations in ILP

Unit VI: Goal Programming

6.1 Goal Programming Formulation
6.2 Goal Programming Algorithms
6.2.1 The Weights Method
6.2.2 The Preemptive Method

Reading List

Essential reading

Taha. H. A. (2013). *Operations research: an introduction*. (9th ed.). Pearson Education India.

Hillier. F. S. (2021). *Introduction to operations research*. (11th ed.). Tata McGraw-Hill Education.
Vanderbei. R. J. (2020). *Linear programming: foundations and extensions* (Vol. 285). Springer Nature.

Additional reading

Bernard W. Taylor III. (1993). *Introduction to Management Sciences*. (4th ed.). New York: Allyn and Bacon.
Kanti Swarup, Manmohan & Gupta. (2018). *Operations Research*. (10th ed.). New Delhi: Sultan Chand and Sons Publishing Co.
Manmohan & Gupta P.K. (1987). *Operations Research and Statistical Analysis*. (3rd ed.). New Delhi: Sultan Chand and Sons Publishers.

Date: March, 2022

AMT312: Stochastic Processes

Module Code & Title: AMT312 Stochastic Processes
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objectives

This module will consider Markov processes in discrete and continuous time. The module also prepares students for undertaking research in the field of operation research, biology and economy.

Learning Outcomes

On completion of the module, students will be able to:

1. Apply the basic concepts of stochastic processes for various real-life problems.
2. Classify stochastic process according to various state space and time domain approach.
3. Apply the different variants of Markov Chain for finding sequence of possible events.
4. Employ Chapman-Kolmogorov equations in identity relating the joint probability distribution of different sets of coordinates on a stochastic process.
5. Construct Ergodic state and Ergodic chain concept which allows to go from every state to every other state with positive probability.
6. Evaluate Random walk and gamblers ruin problem.
7. Apply Birth and death processes to calculate the current size of a population.
8. Apply Queuing processes to model waiting lines so that queue length and waiting times can be predicted.
9. Evaluate the concepts of Epidemic processes as a time-dependent process the state transitions are caused by exposure to some influence.
10. Apply forward and backward Kolmogorov diffusion equations.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours

Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (10%)**

One written assignment will be given in a semester. The written assignment will be given before the mid-semester examination. A set of problems/Theorems (Minimum 7 and maximum 10) spread over at least 50% of the subject matter will be given to the students, which are to be solved by the students independently.

The assignment will be evaluated based on the following criteria:

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

If it is confirmed that a student has plagiarized the assignment, then as per the academic norm, the student will be awarded zero mark or made to redo the assignment based on the convenience of the tutor. In the event where plagiarism is suspected but could not be confirmed, the student in question will be called for viva-voice or asked for oral presentation of the solution. Based on the viva-voice or oral presentation, the tutor will either maintain the initial mark or reduce it.

B. **Laboratory: (30%)**

The laboratory assessment will be carried out as follows:

- **Laboratory Assignment (10%)**

One laboratory assignment worth 10% will be assigned for students to do independently. The module tutor will provide the data on which they will apply the statistical data analysis techniques learned in the laboratory classes and generate a report. The report will be assessed based on the following criteria:

- Abstract 2%
- Diagrammatic/graphical representation 2%
- Identification and calculation of necessary descriptive 3%
- Interpretation of the descriptive and inferential statistics 2%
- Structure of the report 1%

- **Laboratory report (5%)**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam (15%)**

A laboratory exam for the duration of 3 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: (10%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 50 marks and 10% of the scores will be taken as final score.

D. **Semester-end Examination: (50%)**
Semester end Examination for the duration of two and half hours will be for 50 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Laboratory Assignment	1	10%
	Laboratory Report	10	5%
	Laboratory Exam	1	15%
C. Mid-Semester Examination		1	10%
D. Semester-end Examination		1	50%

Prerequisite: PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Introduction to Stochastic process

1.1 Definition and examples of Stochastic Processes (SPs)
1.2 Classification of random processes according to
  1.2.1 State space
  1.2.2 Parameter space
1.3 Types of SPs
  1.3.1 Weakly stationary and strongly stationary processes
  1.3.2 Independent and Identically distributed (iid) process
  1.3.3 White Noise process
  1.3.4 Random Walk process
  1.3.5 Relation between strong and weak Stationarity

Unit II: Discrete-time Markov Chains (DTMCs)

2.1 Definition and examples of Markov Chains
2.2 Transition probability matrix
2.3 Chapman-Kolmogorov equations
2.4 Calculation of n-step transition probabilities
2.5 Limiting probabilities
2.6 Classification of states of a Markov chain as transient, null, recurrent, periodic, aperiodic and Ergodic.

2.7 Ergodicity
2.8 Stationary distribution
2.9 Transient Markov Chain
2.10 Random walk and gambler's ruin problem application.

Unit III: Continuous-time Markov Chains (CTMCs)

3.1 Kolmogorov- Feller differential equations
3.2 Infinitesimal generator
3.3 Poisson process
3.4 Birth-death process
3.5 Stochastic Petri net

Unit IV: Brownian Motion and Martingale

4.1 Wiener process as a limit of random walk
4.2 Process derived from Brownian motion
4.3 Stochastic differential equation
4.4 Stochastic integral equation
4.5 Ito formula
4.6 Some important Stochastic differential equations (SDEs) and their solutions
    4.6.1 Geometric Brownian Motion
4.7 Applications to finance.
    4.7.1 Direct application
    4.7.2 Ornstein-Uhlenbeck process
    4.7.3 Vasicek interest rate model
4.8 Martingale
    4.8.1 Conditional expectations
    4.8.2 Definition and examples of martingales.

Unit V Renewal and Branching Process

5.1 Renewal function and its properties
5.2 Renewal theorems, cost/rewards associated with renewals
5.3 Markov renewal and regenerative processes
5.4 Non-Markovian queues
5.5 Applications of Markov regenerative processes.
5.6 Definition and examples branching processes
5.7 Probability generating function
5.8 Mean and variance
5.9 Galton-Watson branching process
5.10 Probability of extinction.

Unit VI: Stochastic Simulations

6.1 Random Number Generation
6.2 Simulation of random variables: Discrete and continuous
    6.2.1 The Method of Inverse Functions
    6.2.2 The Box-Muller method
6.3 Monte Carlo integration

List of Laboratory Sessions

1. Calculation of probability of moving from one state to other state in Markov chain process
2. Exact simulation of birth and death process

3. A simple simulation of Brownian motion
4. Brownian Motion with Exponential Arrive Displacement
5. Estimation of renewal function
6. Calculate the probability of extinction
7. Simulation using method of inverse functions and Box-Muller method
8. Estimation of estimate using Monte Carlo simulation method

Reading List

Essential Reading

Bhat, B. R. (2000). *Stochastic Models*: *Analysis and Applications*, New Age International, New Delhi.
Medhi, J. (2001). *Stochastic Processes*, Wiley Eastern Ltd., New Delhi.
Ross, S. (2008). *Stochastic Processes* (2 ed.). Wiley.

Additional Reading

Adke, S. R., and Manjunath, S. M. (1984). *An Introduction to Finite Markov Processes*, John Wiley, New Delhi.
Bailey, N. T. J. (1990). *Elements of Stochastic Processes with Applications to the Natural Sciences*, Wiley Eastern Ltd., New Delhi.

Date: March, 2022

IST306: Multivariate Analysis

Module Code & Title: IST306 Multivariate Analysis
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

The module will introduce students to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods. The module also helps the students in having a better understanding of research data, its presentation and analysis. The module will be delivered through the use of R and Spreadsheet.

Learning Outcomes

On completion of the module, students will be able to:

1. Determine marginal and conditional distributions of multivariate normal distribution.
2. Apply the Wishart distribution for appropriate datasets.
3. Apply Hotelling's T^2 for testing hypothesis for multivariate data.
4. Determine the distance between clusters using Mahalanobis' D^2 statistics.
5. Apply the concepts of Wilk's Lambda for testing appropriate hypothesis.
6. Allocate different source of variation using MANOVA.
7. Classify items into groups by using discriminant analysis.
8. Make groups and allocate items into groups using cluster analysis.
9. Find the correlation between two sets of variables using canonical correlations (CC).

10. Apply principal component analysis (PCA) as a bridge between two analyses.
11. Conduct factor analysis and describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables.
12. Apply PCA and CC as a data reduction technique.

Learning and teaching approach

Type	**Approach**	**Hours per week**	**Total credit hours**
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment (10%)**

A written assignment will be given to an individual student during second half of the semester to test the understanding of basic techniques employed while analyzing multivariate data for the purpose of grouping, classifying or data reduction.

The assignment will be assessed based on following criteria:

- Correctness of the use of the appropriate multivariate technique: 4%
- Use of appropriate examples: 2%
- Presentation of the assignment: 4%

B. **Laboratory Assignment (25%)**

- **Laboratory report – 5%**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Lab exam – 20%**

A lab exam for the duration of 2 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 50 marks and 15% of the scores will be taken as final score.

D. **Semester-end Examination: (50%)**

Semester end Examination for the duration of two and half hours will be for 50 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Lab	Lab Report	10	5%
	Lab Exam	1	20%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	50%

Prerequisites: ALG108 Matrix Analysis and Vector Spaces, DST101 Descriptive Statistics and PLT203 R Programming for Data Analysis

Subject Matter

Unit I: Multivariate data

1.1 Some basics of matrix and vector algebra
- 1.1.1 Vectors
- 1.1.2 Matrices

1.2 Positive definite matrices

1.3 A square-root matrix

1.4 Random vectors and matrices

1.5 Mean vector & covariance matrices
- 1.5.1 Partitioning the covariance matrix
- 1.5.2 The mean vector and covariance matrix for linear combination of random variables
- 1.5.3 Partitioning the sample mean vector and covariance matrix

1.6 Joint, marginal and conditional distributions

Unit II: Introduction to Multivariate Normal Distribution

2.1 Definition of multivariate normal distribution

2.2 Probability density function of multivariate normal distribution

2.3 Properties of multivariate normal distribution

2.4 Derivation of marginal probability density function of multivariate normal distribution

2.5 Derivation of conditional probability density function of multivariate normal distribution

2.6 Expectation and variance-covariance matrix

2.7 Joint distributions of multivariate normal distribution

2.8 Conditional distributions and independence of random vectors

2.9 Multinomial distribution

2.10 Sample mean vector and its distribution

2.11 Maximum likelihood estimates of mean vector and dispersion matrix

Unit III: Distributions and Testing of Hypothesis

3.1 Wishart distribution
- 3.1.1 Definition and notation
- 3.1.2 Some results on Wishart Distribution

3.2 Hotelling's T^2 and null distribution of Hotelling's T^2

3.3 Tests of hypothesis about mean vector

3.4 Mahalanobis' D^2 statistics

3.5 Rao's U statistics and its distribution
3.6 Wilks' Lambda criterion and statement of its properties
3.7 Multivariate analysis of variance (MANOVA) and covariance (MANCOVA).

Unit IV: Techniques of Multivariate Analysis

4.1 Discriminatory analysis
  4.1.1 Discriminant scores for decision
  4.1.2 Discriminant analysis in research work
  4.1.3 Discrimination between composite hypotheses
4.2 Derivation of linear discriminant function (LDF)
4.3 Classification between k multivariate normal populations based on LDF and Mahalanobis D^2
4.4 Cluster analysis: k-means and Hierarchical clustering

Unit V: Data reduction techniques

5.1 Canonical correlations
5.2 Principal components
  5.2.1 Principle components obtained from standardized variables
  5.2.2 Principle components for covariance matrices with special structures
  5.2.3 Summarizing sample variation by principle components
5.3 Factor analysis
  5.3.1 The orthogonal factor model
  5.3.2 Methods of estimation
  5.3.3 Factor rotation and factor scores
  5.3.4 Perspectives and a strategy for factor analysis
5.4 Multi-dimensional scaling
  5.4.1 Definition
  5.4.2 The basic algorithm
  5.4.3 Examples
5.5 Correspondence analysis
  5.5.1 Definition
  5.5.2 Examples
  5.5.3 Algebraic development of correspondence analysis

List of Laboratory Sessions

1. Maximum likelihood estimates of mean-vector and dispersion matrix in Excel and R language.
2. Testing of hypothesis on mean vectors of multivariate normal populations in Excel and R language.
3. Cluster analysis, Discriminant function, Canonical correlation, and Principal component analysis in Excel and R language.
4. Factor analysis. Multivariate analysis of variance and covariance, multidimensional scaling in Excel and R language.

Reading List

Essential Reading

Anderson, T. W. (2003). *An Introduction to Multivariate Statistical Analysis*, John Wiley, New Delhi.

Rao, C. R. (2001). *Linear Statistical Inference and its Applications*, John Wiley, New Delhi

Muirhead, R. J. (2009). *Aspects of Multivariate Statistical Theory*, John Wiley, New Delhi.

Johnson, R. A., and Wichern, D. W. (2008). *Applied Multivariate Statistical Analysis*, Prentice Hall, New Delhi.
Rencher, A. C. (2002). *Methods of Multivariate Analysis*, John Wiley, New Delhi.

Additional Reading

Srivastava, M. S., & Khatri, C. G. (1979). *An Introduction to Multivariate Statistics*, North Holland, New Delhi.
Chatfield, C., & Collins, A. J. (1982). *Introduction to Multivariate Analysis*, Prentice Hall, New Delhi.

Date: March, 2022

PMT301: Project Design and Management

Module Code and Title: PMT301 Project Design and Management
Programme: B.A Population and Development Studies
Credit Value: 12
Module Tutor: Tashi Dorji & Yeshey Wangmo
Module Coordinator: Tashi Dorji

General Objective

This module will enable students to acquire knowledge on the principle aspects of project management and equip them with project management skills. The module will introduce project management concepts and terminologies. It will also enable students to solve practical problems and apply some of the project management tools and techniques.

Learning Outcomes

On the completion of this module, students will be able to:

- Explain the key concepts and terminologies of project management
- Discuss the steps and process of project management cycle
- Discuss reasons for initiating projects or programme
- Identify major milestones in each stage of the project cycle
- Identify major management functions including planning and supervision, leadership, teamwork and effective field based monitoring of progress
- Apply Logical Framework Approach (LFA) for result-based planning
- Develop project proposal
- State the differences between monitoring and evaluation
- Carry out a case study to apply the skills and knowledge of project management

Learning and Teaching Approach

Approach	Hours per Week	Total Credit Hours
Lecture	3	45
Tutorials	1	15
Case Study	2	30
Independent Study	2	30
Total		**120**

Assessment approach

Assessments will be carried out on a continuous basis through the following assignments:

A. Case Study/Project Analysis: Portion of Final Mark: 35%
Students will be given two choices to conduct case study/project analysis. Students attempting first choice, have to visit a problem area to understand and identify the type of project that would benefit the community. The project proposal will be graded based on the following criteria:

- Business case development (clarity of problem statement and feasibility of solutions): 10%
- Planning (Resource, quality, communication and procurement planning): 10%
- Execution or implementation of project (Monitoring and Control using various management mechanism): 10%
- Project closure (presentation of deliverables): 5%

Students attempting 2nd choice have to visit project initiated areas to assess project framework, management and monitoring process. Students have to critical review all these aspects and marks will be provided based on following criteria:

- Understanding project design, management and monitoring process : 10%
- Critical evaluation of project design, management and monitoring process (Identifying key challenges/issues): 15%
- Recommendation of best practices: 10%

B. Presentation: Portion of Final Mark: 15%
Based on the case study, student will make one presentation for duration of 20 minutes. The presentation will be assessed based on the following criteria:

- Content: 7%
- Discussion: 5%
- Presentation skills: 3%

C: Semester End Examination: Portion of Final Mark: 50%
Semester end examination carries 50%. It will be conducted for the duration 3 hours.

Overview of the assessment approaches and weighting

Area of Assessment	**Quantity**	**Weighting**
A. Case Study	1	30%
B. Presentation	1	20%
C. Semester End Examination	1	50%
Total		**100%**

Pre-requisite: None

Subject Matter
Unit I: Introduction to Project Management
1.1. Definition and concepts of Project, Programme and Portfolio
1.2. Programme, project and portfolio management
1.3. Project life cycle
1.4. Project and programme manager and related concepts
1.5. Responsibilities and Competencies
1.6. Importance of initiating project
Unit II: Project Initiation
2.1. Develop Business case
2.2. Undertake Feasibility study

2.3. Establish Terms of Reference
2.4. Appoint Project Team
2.5. Set up Project Office

Unit III: Project Planning
3.1. Project plan
3.2. Resource plan
3.3. Financial plan
3.4. Quality plan
3.5. Risk plan
3.6. Acceptance plan
3.7. Communication plan
3.8. Procurement plan
3.9. Identifying Supplier

Unit IV: Project Execution
4.1. Building deliverables
4.2. Monitor and Control
4.3. Time Management
4.4. Cost and Quality Management
4.5. Change and Risk Management
4.6. Issue and Procurement Management
4.7. Acceptance and Communication Management

Unit V: Project Closure
5.1. Perform Project Closure
5.2. Review Project Completion
5.3. Evaluation of Project; meanings, concepts and its importance

Reading List
Essential Reading
Charvat, J. (2003). *Project management methodologies: selecting, implementing, and supporting methodologies and processes for projects*. John Wiley & Sons.
Duncan, W. R. (1996). A guide to the project management body of knowledge.
Horine, G. (2009). *Absolute beginner's guide to project management*. Pearson Education.
Kerzner, H. R. (2013). *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.
Khatua, S. (2011*). Project management and appraisal*. Oxford University Press.
Meredith, J. R., Mantel, S. J., & Shafer, S. M. (2016). *Project management: a managerial approach*. Singapore: Wiley.
Potts, D. (2002). *Project planning and analysis for development*. Boulder: Lynne Rienner
Project Management Institute. (2014). *A guide to the project management body of knowledge - pmbok guide.* Project Management Inst.

Additional Reading
A guide to the project management body of knowledge: PMBOK® guide. (2013). Newton Square: Project Management Institute.
Hansen, J. R. (1986). *Guide to practical project appraisal: social benefit-cost analysis in developing countries*. Vienna: United Nations Industrial Development Organization.
Kerzner, H. R. (2002).*Strategic planning for project management using a project management maturity model*. John Wiley & Sons.

Pinto, J. K., & Pearson. (2016). *Project management: achieving competitive advantage*. Boston: Pearson.

Year 4: Semester I

AST407: Mathematical Demography and Actuarial Statistics

Module Code & Title: AST407 Mathematical Demography and Actuarial Statistics
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
This module will provide students with knowledge on identifying appropriate sources of data, perform basic demographic analyses using various techniques and ensure their comparability across populations. The module will also enable students to produce population projections and interpret the information gathered by the different demographic methods

Learning Outcomes
On completion of the module, students will be able to:

1. Evaluate the advantages and disadvantages of the different sources of demographic data
2. Construct appropriate techniques to ensure comparability of the measures across population
3. Interpret basic demographic indicators and elaborate on their computation.
4. Apply population projection calculations and analysis
5. Identify the different sources of data
6. Explain the demographic concepts, terminology and formulas
7. Explain the key assumptions underlying techniques and tools.
8. Construct the distribution of a population using various demographic characteristics
9. Apply life-table model in mortality estimation

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory session	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

A. Assignment: (15%)
This assignment will be given during the first half of the semester. It will comprise of problem solving and application questions. It will cover more than 40% of the subject matter. This assignment be given to the students at the end of week 4 and students will be given three weeks to complete the assignment. Students will have to work individually. The assignment will be assessed based on the following criteria:

- Understanding of Comparative survey 4%
- knowledge and Understanding of Statistical Analysis 7%
- Communication Skills (Ability to organize and convey the information) 4%

B. Presentation: The portion of final mark: (15%)

Students will be divided in a group of 3-5 depending on the cohort, they will read and present an academic paper. In addition, students will have to consider some type of "extension". This may be by simplifying the problem and considering another estimator and its properties, extending the inferential method, or even considering other data sets. Each presentation will last 15-20 minutes and each member of the group must speak. Every presenter in a group will be given the same grade. All paper choices must be approved by the tutor. The presentation will be assessed based on the following criteria:

- Clarity in stating the problem 3%
- Identification of important variables 2%
- Appropriateness of methods and materials 4%
- Extent to which the conclusion is supported by the data 3%
- Extension 3%

C. Laboratory: The portion of final mark(30%):

Laboratory assignment is divided into two components:

Laboratory Report (10%): Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 500 to 750 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 3 marks
Results	- 3 marks
Interpretation/ conclusion	- 3 marks

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

Laboratory Exam (20%): Students will sit for a laboratory exam at the end of semester for a duration of three hours. This exam will be on practical application of the skills developed over the course of all the lab sessions and the theory classes.

D. Semester-end Examination: Portion of Final Mark: (40%)

Semester end Examination for the duration of two will be for 40 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	15%
B. Presentation		1	15%
C. Laboratory	Laboratory Report	10	10%

	Laboratory Exam	1	20%
D. Mid-Semester Examination		1	40%

Prerequisite: None

Subject Matter

Unit I: Introduction

1.1 Sources of vital statistics in Bhutan
1.2 Functions of vital statistics
1.3 Rates and ratios mortality rates-crude
1.4 Age specific and standard death rates
1.5 Fertility and reproduction rates
1.6 Crude birth rates-general
1.7 Specific fertility rates-gross
1.8 Net reproduction rates

Unit II: Life Tables

2.1 Complete life tables and its characteristics
2.2 Abridged life tables and its characteristics
2.3 Principle methods of construction of abridged life tables
2.4 Reed Merrel's method

Unit III: Relationships between Life Table Functions

3.1 Relation between l(x) and L(x)
3.2 Relation between l(x) and T(x)
3.3 Relation between mortality rates q(x) and m(x)
3.4 Relation between q(x) and $\mu(x)$
3.5 A relation between e_x^0 and $\mu(x)$
3.6 A relation between m(x) and $\mu(x)$
3.7 A relation between e_x^0 and e_{x+1}^0
3.8 An exact expression for L(x)

Unit IV: Population Growth Indices

4.1 A population density dependent growth model
  4.1.1 The logistic model for population growth
  4.1.2 Properties of logistic curve
4.2 Method of fitting logistic curve
4.3 Population projection techniques

Unit V: Fundamentals of insurance

5.1 Insurance defined meaning of loss
5.2 Peril, hazard and proximate cause in insurance
5.3 Costs and benefits of insurance to society-branches of insurance
5.4 Insurable loss exposures-feature of loss that is deal of insurance
5.5 Construction of Mortality table
5.6 Computation of premium of life insurance for fixed duration and for the whole life.

List of Laboratory Sessions

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by: (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using Reed-Merrell Method
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them

Reading List

Essential Reading

Mukhopadhyay P. (1999). *Applied Statistics*, Books and Allied (P) Ltd.

Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). *Fundamentals of Statistics*, Vol. II, (9 ed.), World Press.

Additional Reading

Biswas, S. (1988). *Stochastic Processes in Demography & Application*, Wiley Eastern Ltd.

Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): *Applied General Statistics*, (3 ed.). Prentice Hall of India Pvt. Ltd.

Keyfitz, N., & Beekman, J. A. (2013). *Demography through problems*. Springer Science & Business Media.

Date: March, 2022

AST408: Design of Experiments

Module Code & Title: IST408 Design of Experiments
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

This module will expose the students to the basic principles of design of experiments. The students would be provided with mathematical background of various basic designs involving one-way and two-way elimination of heterogeneity and their properties. This module also prepares students for undertaking research in this area so that it helps them in applications of this important subject to other sciences. The module will be delivered through the use of R and spreadsheet.

Learning Outcomes

On completion of the module, students will be able to:

1. Apply basic principles of design of experiments to get optimal information from scarce resources.

2. Apply completely randomized design (CRD), randomized complete block design (RCBD) and Latin square design (LSD) for treatment comparison.
3. Analyze the uses of mutually orthogonal Latin squares and Graeco Latin squares.
4. Construct balanced incomplete block (BIB) designs using various methods of construction.
5. Apply groups of experiments to combine experiments carried out in different stations or years.
6. Impute the values using missing plot techniques in analysis of experimental designs.
7. Apply multiple comparison procedures to find the differences between treatments.
8. Apply response surface methodology to estimate the optimal combinations of treatment.
9. Execute second order rotatable designs to find the optimal combinations of treatment combinations in a factorial set up.

Learning and teaching approach

Type	**Approach**	**Hours per week**	**Total credit hours**
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (5%)**

A written assignment will be given to an individual student in a semester to test the understanding of basic concepts of design of experiments as well as the different applications of various designs employed by statisticians to make treatment comparison under various practical conditions.
The assignment will be assessed based on following criteria:

- Correctness of the use of the three principles of design of experiments: 2 marks
- Use of appropriate ANOVA: 1 mark
- Use of appropriate examples: 1mark
- Presentation: 1 mark

B. **Laboratory Assignment: (20%)**

- **Lab report – 5%**

Students will submit a weekly record of the lab session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Lab exam – 15%**

A lab exam for the duration of 2 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of three hours. Examination will be conducted out of 60 marks and 15% of the scores will be taken as final score.

D. **Semester-end Examination: (60%)**

Semester end Examination for the duration of three hours will be for 60 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	5%
B. Laboratory	Report	10	5%
	Exam	1	15%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	60%

Prerequisites: None

Subject Matter

Unit I: Concept of Design of Experiments

1.1 Basic principles of design of experiments: Randomization, Replication, and Local control.
1.2 Uniformity trials.
1.3 Fertility contour maps.
1.4 Size and shape of plots and blocks.
1.5 Elements of linear estimation.
1.6 Analysis of variance and covariance.

Unit II: Basic Designs

2.1 General properties and analysis of block designs.
2.2 Completely randomized design (CRD).
2.3 Randomized complete block design (RCBD).
2.4 Latin square design (LSD).
2.5 Mutually orthogonal Latin squares (MOLS).
2.6 Graeco Latin squares.
2.7 Layout, model and statistical analysis, relative efficiency, analysis with missing observations.

Unit III: Factorial Experiments

3.1 Factorial experiments.
3.2 Advantages, notations and concepts of factorial experiments.
3.3 Layout, model and statistical analysis of factorial experiments.
3.4 Confounding in symmetrical factorial experiments.
3.5 Balanced factorial experiments.

Unit IV: Variants of factorial experiments

4.1 Split plot designs.
4.2 Strip-plot designs.
4.3 Youden square designs.
4.4 Groups of experiments.

Unit V: Incomplete Block Designs

5.1 Balanced incomplete block (BIB) designs.
5.2 Parameters of BIBD, relationships among its parameters.
5.3 Incidence matrix and its properties.
5.4 Symmetric BIBD.
5.5 Construction of BIB designs.

Unit VI: Variants of Block design

6.1 Designs for test treatment – control(s) comparisons.
6.2 Response surface designs.
6.3 Second order rotatable designs.
6.4 Multiple comparison procedures.

List of Laboratory sessions

1. Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law in Excel and R language.
2. Analysis of data obtained from CRD, RBD, LSD in Excel and R language.
3. Analysis of factorial experiments in R language.
4. Analysis of covariance, analysis with missing data, split plot and strip plot designs in R language.
5. Analysis of groups of experiments in R.
6. Analysis of BIBD in R.
7. Analysis of second order response surface designs in R.

Reading Lists

Essential Reading

Dean, A. M., & Voss, D. (1999). *Design and Analysis of Experiments*, Springer, New Delhi.
Dey, A. (1986). *Theory of Block Designs*, Wiley Eastern Ltd., New Delhi.
Jones, B., & Montgomery, D. C. (2019). *Design of Experiments: A Modern Approach*, Wiley, New Jersey.
Lawson, J. (2015). *Design and Analysis of Experiments with R,* CRC Press, Florida.
Morris, M. (2011). *Design of Experiments: An introduction based on linear models,* CRC Press, Florida.

Additional Reading

Cochran, W. G., & Cox, G. M. (1992). *Experimental Designs*, John Wiley, New Delhi.
Hinkelmann, K., and Kempthorne, O. (1994). *Design and Analysis of Experiments*, John Wiley, New Delhi.
Fisher, R.A. (1971). *Design and Analysis of Experiments*, Oliver and Boyd, Edinburg.

Date: March, 2022

MQM405: Econometrics

Module Code & Title: MQM405 Econometrics
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

This module aims at familiarizing the students in econometric methods and their applications. This module would enable the students in understanding the economic phenomena through statistical tools and economics principles. The module will be delivered through the use of R and spreadsheet.

Learning Outcomes

On completion of the module, students will be able to:

1. Apply generalized linear model (GLM) for fitting data for econometric variables.
2. Make use of dummy variables to study categorical effects.
3. Make appropriate transformations to capture the heteroscedastic behavior of datasets.
4. Apply the basic concepts of random processes for model fitting.
5. Perform mixed model and random models to analyze given data.
6. Perform remedies for problems of multicollinearity in the datasets.
7. Fit a parsimonious model when the number of predictor variables in a set exceeds the number of observations.
8. Develop autoregressive linear regression model.
9. Develop distributed lag models.
10. Estimate the parameters of simultaneous linear equation models.
11. Select appropriate model on the basis of model selection criteria.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory session	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	
Total			**120**

A. **Assignment (10%):**

A written assignment will be given to an individual student in second half of the semester to test the understanding of General Linear model (GLM) for analyzing bivariate or multivariate data for the purpose of finding “cause and effect” relationship between dependent and independent variable/s.

The assignment will be assessed based on following criteria:

- Choice of appropriate data: 1%
- Testing of major assumptions of General Linear model: 2%
- Testing of hypothesis (Whether beta coefficients are significant or not): 1%
- Residual Analysis: 2%
- Presentation of the assignment: 4%

B. **Laboratory Assignment (25%):**

- **Laboratory report – 5%**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory exam – 20%**

A laboratory exam for the duration of 2 hours will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination (15%):**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 50 marks and 15% of the score will be taken as final score.

D. **Semester-end Examination (50%)**:

Semester end Examination for the duration of two and half hours will be conducted for 50 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	10%
B. Laboratory	Laboratory Report	10	5%
	Laboratory Exam	1	20%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	50%

Prerequisite: ECO101 Fundamentals of Economics

Subject Matter

Unit I: Concepts of Econometrics

1.1 The general linear model (GLM): Concept and proof.
1.2 Generalized least squares (GLS): Estimation and prediction.
1.3 Use of dummy variables and seasonal adjustment.
1.4 Heteroscedastic disturbances: Testing and remedies.
1.5 Auto correlation: Consequences and tests.
1.6 Theil BLUS procedure: Estimation and prediction.
1.7 Problem of multicollinearity, its implications and tools for handling the problem.
1.8 Ridge regression as one of the tool to tackle multicollinearity.
1.9 Linear regression with stochastic regressors: concept.
1.10 Errors in variables.
1.11 Autoregressive linear regression: Concept, derivation and proof.
1.12 Distributed lag models: Concept, derivation, and proof.

Unit II: Simultaneous Linear Equations (SLS) Model

2.1 Identification problem of simultaneous linear equations model.
2.2 Restrictions on structural parameters - rank and order conditions.
2.3 Restrictions on variances and covariances.
2.4 Estimation in simultaneous equations model.
2.5 Recursive systems.
2.6 Two SLS Estimators.
2.7 Limited information estimators.
2.8 K - class estimators.
2.9 Three SLS estimation technique.
2.10 Full information maximum likelihood method.
2.11 Prediction and simultaneous confidence intervals.

Unit III: Model Specification and Diagnostic Testing

3.1 Model selection criteria.
3.2 Types of specification errors.
3.3 Consequences of model specification errors.
3.4 Tests of specification errors.
3.5 Errors of measurement.

Unit IV: Panel Data Regression Models

4.1 Panel data regression
- 4.1.1 Definition and concept
- 4.1.2 Model Specification

4.2 Pooled OLS regression or constant coefficient model
- 4.2.1 Concept and model set-up
- 4.2.2 Estimation of parameters
- 4.2.3 Testing significance of parameters
- 4.2.4 Interpretation of the results

4.3 The fixed effect panel data model
- 4.3.1 Concept and model set-up
- 4.3.2 Estimation of parameters
- 4.3.3 Testing significance of parameters
- 4.3.4 Interpretation of the results

4.4 The random effect panel data model
- 4.4.1 Concept and model set-up
- 4.4.2 Estimation of parameters
- 4.4.3 Testing significance of parameters
- 4.4.4 Interpretation of the results

List of Laboratory Sessions

1. Fitting of single equation linear regression models: maximum likelihood, ordinary least-squares and generalized least squares methods of estimation in Excel and R language.
2. Detection and handling of heteroscedasticity, auto-correlation in Excel and R language.
3. Fitting of distributed lag models in Excel and R language.
4. Full information maximum likelihood method, Prediction and simultaneous confidence intervals in Excel and R language.
5. Fitting of panel data regression in Excel and R language.

Reading List

Essential Reading

Gujarati, D. N. (2004). *Basic Econometrics*, Tata McGraw Hill, New Delhi.

Gujarati, D. N., & Porter, D. C. (2010). *Basic Econometrics*, Tata McGraw Hill, New Delhi.
Koop, G. (2007). *Introduction to Econometrics*, John Wiley, New Delhi.
Wooldridge, J. M. (2006). *Introductory Econometrics: A Modern Approach*, Cengage Learning, Ohio.
Greene, W. H. (2007). *Econometric Analysis*, Prentice Hall, New Jersey.

Additional Reading

Maddala, G. S. (2001). *Introduction to Econometrics*, John Wiley, New Delhi.
Pindyck, R. S., and Rubinfeld, D. L. (1998). *Econometric Models and Economic Forecasts*, Tata McGraw Hill, New Delhi.
Verbeek, M. (2008). *A Guide to Modern Econometrics*, John Wiley, New Delhi.

Date: March, 2022

IST409: Forecasting Techniques and Statistical Modelling

Module Code & Title: IST409 Forecasting Techniques and Statistical Modelling
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dr. Bishal Gurung

General Objective

This module aims at familiarizing the students in construction of index number, modelling and forecasting using nonlinear growth models and time-series models. This helps prepare students for applications of this important subject to real datasets. It also aims at describing some advanced level topics in this area of research with a very strong potential of applications. The module will be delivered through the use of R, spreadsheet and gretl.

Learning Outcomes

On completion of the module, students will be able to:

1. Construct index numbers using different methods.
2. Calculate the cost-of-living index.
3. Apply time-series techniques for modelling and forecasting sequentially collected data.
4. Apply Box-Jenkins methodology for estimation of parameters, testing the parameters for significance and prediction.
5. Apply weather variables to model and forecast the yield of crops.
6. Derive indices to be employed for modeling and forecasting.
7. Apply concepts for forewarning of crop pests and diseases.
8. Apply various machine learning techniques process in forecasting.
9. Apply nonlinear growth models for modeling and forecasting and make mechanistic interpretation.
10. Estimate the parameters of nonlinear models using different procedures.
11. Apply statistical measures to calculate the goodness of fit of different modelling techniques.

Learning and teaching approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	

Independent Study	Written assignment	1	**60**
	Self-study	3	
Total			**120**

Assessment Approach

A. **Assignment: (15%)**

A major written assignment will be given to an individual student during second half of the semester. The assignment will be based on analysis of data obtained from the website of National Statistics Bureau (NSB). Appropriate growth or time-series model is to be employed taking into consideration the characteristic features of the data.

The assignment will be assessed based on following criteria:

- Choice of appropriate data: 2%
- Checking the characteristic features of the data: 3%
- Selection of appropriate model for the data under consideration: 5%
- Residual Analysis: 3%
- Presentation of the assignment: 2%

B. **Laboratory Assignment: (30%)**

- **Laboratory report – 10%**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory exam – 20%**

A laboratory exam for the duration of 2 hours will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination (15%):**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two hours. Examination will be conducted out of 40 marks and 15% of the scores will be taken as final score.

D. **Semester-end Examination (40%):**

Semester end Examination for a duration of two hours will be conducted for 40 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		**Quantity**	**Weighting**
A. Assignment		1	15%
B. Lab	Lab Report	10	10%
	Lab Exam	1	20%

C. Mid-Semester Examination	1	15%
D. Semester-end Examination	1	40%

Prerequisite: AMT312 Stochastic Processes

Subject Matter

Unit I: Index Number

1.1 Introduction
1.2 The problem of Index Number
1.3 Construction of Index number:
  1.3.1 Ratio of simple aggregates
  1.3.2 Procedures using ratio weighted aggregates
  1.3.3 Using unweighted average of price relatives
1.4 Properties
1.5 Some well-known index number formulae
1.6 Problem of construction of index numbers
1.7 Chain indices
1.8 Cost of living indices
1.9 Splicing of index numbers
1.10 Different types of index numbers used.

Unit II: Time-series analysis

2.1 Components of time series
2.2 Measuring trends
2.3 Forecast based on time series data.
2.4 Exponential smoothing.
2.5 Box - Jenkins ARIMA and SARIMA approach.
2.6 Parameter estimation using maximum likelihood method.
2.7 Parameter estimation using ordinary least-squares method.
2.8 Forecast models for :
  2.8.1 weather parameters.
  2.8.2 GDP growth, consumption, government investment, and CPI
  2.8.3 Exchange rate, liquidity, and reserves
2.9 Crop-weather relationships and their use in yield forecast.
2.10 Forewarning using statistical models of crop pests and diseases.

Unit III: Statistical modelling

3.1 Introduction to statistical modeling.
3.2 Different types of models.
3.3 Empirical and mechanistic models.
3.4 Parametric and Non-parametric models.

Unit IV: Nonlinear growth models

4.1 Malthus growth model.
4.2 Monomolecular growth model.
4.3 Logistic growth model.
4.4 Gompertz growth model.
4.5 Richards growth model.
4.6 Formulation of nonlinear statistical models.
4.7 Application of nonlinear statistical models.

Unit V: Parameter estimation techniques

5.1 Estimation of parameters of nonlinear growth models using Taylor's method.
5.2 Estimation of parameters of nonlinear growth models using Steepest descent method.
5.3 Estimation of parameters of nonlinear growth models using Levenberg - Marquardt's method.
5.4 Estimation of parameters of nonlinear growth models using *doesn't use derivatives (DUD) method.*
5.5 Choice of initial values of the parameters.
5.6 Examination of residuals and adequacy of a model.
5.7 Fitting of nonlinear statistical models using nonlinear estimation procedures and software packages.

List of Laboratory sessions

1. Construction of index number in Excel and R language.
2. Fitting of forecast models in Excel and R language.
3. Exercise on Time series analysis: plots, decomposition, stationarity tests, exponential smoothing in Excel and R language.
4. Fitting of Univariate Box - Jenkins ARIMA models and seasonal ARIMA models in Excel and R language.
5. Estimation of forecast models using plant characters, Agrometeorological models for crop forecasting in Excel and R language.
6. Fitting of mechanistic nonlinear models using nonlinear estimation procedures in Excel and R language.

Reading List

Essential Reading

Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (2016). *Time Series Analysis: Forecasting and Control*, Pearson Education, New Delhi.

Hyndman, R. J., & Athanasopoulos, G. (2013). *Forecasting: Principles and Practice*, OTexts: Melbourne

Makridakis, S., Wheelwright, S.C., and Hyndman, R. J. (1998). *Forecasting: Methods and Applications*, John Wiley, New Delhi.

Metcalfe, A. V. & Cowpertwait P. S. P. (2009). *Introductory Time Series with R*, Springer, New Delhi.

Tsay, R. S. (2010). *Analysis of Financial Time-series*, Wiley, New Delhi.

Additional Reading

Brockwell, P. J., and Davis, R. A. (1996). *Introduction to Time Series and Forecasting*, Springer Verlag, New Delhi.

Draper, N. R., and Smith, H. (1998). *Applied Regression Analysis*, John Wiley, New Delhi.

Ratkowsky, D. A. (1990). *Handbook of Nonlinear Regression Models*, Marcel Dekker, London.

Seber, G. A. F., and Wild, C. J. (1989). *Nonlinear Regression*, John Wiley, New Delhi.

Date: March, 2022

DSC201 Machine Learning

Module Code & Title: DSC201 Machine Learning

Programme: BSc in Data Science
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective
The objective of this module is to introduce formal definition of Machine Learning and continues on with explanations for the various machine learning and training techniques. Module also review both Supervised and Unsupervised learning, showcasing the main differences between each type of learning method.

Learning Outcomes
On completion of the module, students will be able to:

1. Explain the different Machine Learning training techniques.
2. Explain the difference between Supervised and Unsupervised training.
3. Differentiate between Classification and Regression.
4. Apply Neural Network in supervised learning.
5. Interpret results from scikit-learn estimators
6. Explain the tradeoffs inherent in different machine learning methods: speed, accuracy, complexity of hypothesis space, etc.
7. Explain issues of algorithmic bias, transparency, fairness in supervised machine learning applications.
8. Apply regression and classification objects (estimators) in scikit-learn.
9. Apply a wide variety of evaluation metrics to supervised learning scenarios.

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**75**
	Laboratory Session	2	
Independent study	Written Assignment	1	**45**
	Self-study	2	
Total			**120**

Assessment Approach

A. **Problem-solving Assignment: (10%)**
The assignment will be given during the first half of the semester. The assignment will comprise of problem-solving based on some questions provided to them. Assignments will be assessed using following criteria:

- Correctness of the solutions: 4%
- Logical flow in the process: 2%
- Uniqueness of the solution: 2%
- Use of appropriate terms and symbols: 2%

B. **Laboratory: (35%)**
Lab assessment will be carried out as follows:

- **Laboratory report- 10%**
  Students will submit a weekly record of the lab session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500

words based on the nature of the practical. They will be assessed using the following marking criteria:

Objective	- 1 mark
Method description	- 2 marks
Results	- 1 mark
Interpretation/ conclusion	- 1 mark

At the end of all the lab sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam- 25%**

A lab exam for the duration of 3 hour will be conducted towards the end of a semester after the last day of regular teaching.

C. **Mid-Semester Examination: The portion of Final Marks: (15%)**

Mid-semester Examination will be conducted in the mid of semester with at least 60% of the subject matter being covered for the duration of two and half hours. Examination will be conducted out of 40 marks and 15% of the scores will be taken as final score.

D. **Semester-end Examination: The portion of Final Marks: (40%)**

Semester end Examination for the duration of two and half hours will be for 50 marks. All the units of the subject matter will be included for the examination.

Overview of assessment approaches:

Areas of Assessment		Quantity	Weighting
A. Problem-solving Assignment		1	10%
B. Lab Assignment	Lab report	10	10%
	Lab exam	1	25%
C. Mid-Semester Examination		1	15%
D. Semester-end Examination		1	40%

Prerequisite: PLT102 Programming in Python, DST101 Descriptive Statistics, IST302 Regression Analysis

Subject Matter

Unit I: Introduction and Basic Concepts

1.3 Definition of Machine Learning
1.4 History/evolution of Machine Learning
1.5 Taxonomy of Machine Learning: A simplistic view based on tasks
1.6 Definition of supervised learning with examples
1.7 Supervised Machine learning setup with examples
1.8 Different types of supervised machine learning (Definition and examples): Regression, Classification, Naïve Bayesian model, Random forest model, Neural Networks, and Support vector machines.
1.9 Regression vs Classification
1.10 Definition of unsupervised learning with examples
1.11 Unsupervised machine learning setup with examples
1.12 Different types of unsupervised machine learning (Definition and examples): Clustering, association

1.13 Definition of reinforcement learning with examples

Unit II: Regression

2.1 Linear regression with one variable:
- 2.1.1 Model Representation
- 2.1.2 Cost function
- 2.1.3 Cost function-intuition
- 2.1.4 Gradient descent
- 2.1.5 Gradient descent -intuition
- 2.1.6 Gradient descent for linear regression

2.2 Linear regression with multiple variables
- 2.2.1 Multiple features
- 2.2.2 Gradient descent for multiple variables
- 2.2.3 Gradient descent in practice: Feature scaling, learning rate
- 2.2.4 Features and Polynomial regression
- 2.2.5 Normal equation
- 2.2.6 Normal equation: Non invertibility

2.3 Regularization
- 2.3.1 Problem of overfitting
- 2.3.2 Cost function
- 2.3.3 Regularized linear regression
- 2.3.4 Hypothesis representation
- 2.3.5 Decision boundary
- 2.3.6 Cost function
- 2.3.7 Simplified cost function and Gradient descent
- 2.3.8 Optimisation
- 2.3.9 Multiclass classification: one -vs-all

Unit III: Classification

3.1 Classification and Representation
3.2 Hypothesis representation
3.3 Decision boundary
3.4 Cost function
3.5 Simplified cost function and Gradient descent
3.6 Optimisation
3.7 Multiclass classification: one-vs-all
3.8 Regularization
- 3.8.1 Problem of overfitting
- 3.8.2 Cost function
- 3.8.3 Regularized logistic regression

3.9 Naïve Bayes
- 3.9.1 Classifier based on Bayes Rule
- 3.9.2 Naïve Bayes Algorithm

3.10 K-Nearest Neighbor
3.11 Decision Tree
3.12 Random Forest
- 3.12.1 Bagging
- 3.12.2 From Bagging to random forest
- 3.12.3 Relationship to nearest neighbors

3.13 Support Vector Machine

3.13.1 Optimisation objective
3.13.2 Large margin intuition
3.13.3 Mathematics behind Large margin classification
3.13.4 Kernels

Unit IV: Neural Network

4.1 Neuron models and basic learning rules
4.2 McCulloch-Pitts neuron model
4.3 Terminologies: Weights, effective input, threshold, activation function
4.4 Generalization of the neuron model: discrete neurons and continuous neurons
4.5 Activation function of continuous neuron: sigmoid function
4.6 A neuron model with augmented input
4.7 Single layer neural network and multi-layer neural network
4.8 Basic steps for using a neural network
4.8.1 Learning
4.8.2 Recall
4.8.3 Basic diagram of learning and Recall
4.9 General learning rule for one neuron
4.10 Perception learning rule
4.11 Delta Learning rule
4.12 Multilayer neural networks and back- propagation

List of Laboratory Sessions

1. Explore the relationship between model complexity and generalization performance, by adjusting key parameters of various supervised learning models. Part 1 of this lab will look at regression and Part 2 will look at classification.
2. Write a function that fits a polynomial Linear Regression model on the *training data* `X_train` for any degree.
3. Train two models: a non-regularized Linear Regression model (default parameters) and a regularized Lasso Regression model (with parameters `alpha=0.01`, `max_iter=10000`) on polynomial features of any degree. Return the R squared score for both the Linear Regression and Lasso model's test sets.
4. Using any two training data, train a DecisionTreeClassifier with default parameters and random_state=0. Then identify important features found by the decision tree.
5. Write Program for Perception learning and Delta rule.
6. Write program to Classify data using one neuron.
7. Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
8. Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Calculate the accuracy, precision, and recall for your data set

Reading List
Essential Reading

Albon, C. (2018). Machine learning with python cookbook: Practical solutions from preprocessing to deep learning. " O'Reilly Media, Inc.".

Coelho, L. P., & Richert, W. (2015). Building machine learning systems with Python. Packt Publishing Ltd.

Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J. (2005). Data mining: practical machine learning tools and techniques (Morgan-Kaufman Series of Data Management Systems).

Additional Reading

Bowles, M. (2015). Machine learning in Python: essential techniques for predictive analysis. John Wiley & Sons.
Garreta, R., & Moncecchi, G. (2013). Learning scikit-learn: machine learning in python. Packt Publishing Ltd.

Date: March, 2022.

Year 4: Semester II

IST410: Survival Analysis and Biostatistics

Module Code & Title: IST410 Survival Analysis and Biostatistics
Programme: BSc in Statistics
Credit Value: 12
Module Tutor: Dechen Wangdi

General Objective

This module covers the tools for the collection, analysis, and presentation of data in all areas of public health. The module also provides students with skills for assessing the impact of chance and variability on the interpretation of research findings and subsequent recommendations for public health practice and policy.

Learning Outcomes

On completion of this module, the students will be able to:

1. Derive the survival time density function, survival function, and hazard function
2. Construct a life table using the Kaplan-Meier approach
3. Perform a log-rank test to compare two survival curves
4. Apply the cox proportional hazards model to compare survival experience
5. Identify problems falling in survival analysis framework
6. Identify applications with time to event outcome
7. Summarize the measures for the main quantities used in survival analysis
8. Validate the regression models used in survival analysis and their interpretation
9. Communicate the results of statistical analyses accurately and effectively

Learning and Teaching Approach

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**60**
	Laboratory sessions	1	
Independent Study	Written assignment/Quizzes	1	**60**
	Self-study	3	

Total	**120**

Assessment Approach

A. Assignment (15%)

This assignment will be given during the first half of the semester. It will be comprised of problem solving and application questions. It will cover more than 40% of the subject matter. This assignment be given to the students at the end of week 4 and students will be given three weeks to complete the assignment. Students will have to work individually. The assignment will be assessed based on the following criteria:

- Understanding of Comparative survey 4%
-knowledge and Understanding of Statistical Analysis 7%
- Communication Skills (Ability to organise and convey the information) 4%

B. Presentation (15%)

In groups, students will read and present an academic paper. In addition, students will have to consider some type of "extension". This may be by simplifying the problem and investigating which parametric models would be appropriate to model the data, or even considering other data sets. Students will have to discuss how they reached their conclusion regarding the best parametric model for this data. The topics will be finalised by the end of week 7 and presentations will be conducted in week 13 or week 14. Each presentation will last 15-20 minutes and each member of the group must speak. Every presenter in a group will be given the same grade. All paper choices must be approved by the tutor. The presentation will be assessed based on the following criteria:

- Clarity in stating the problem 3%
- Identification of important variables 2%
- Appropriateness of methods and materials 4%
- Extent to which the conclusion is supported by the data 3%
- Extension 3%

C. Laboratory (30%)

Laboratory assignment is divided into two components:

- **Lab Report (10%)**

Students will submit a weekly record of the laboratory session to keep track of his/her progress which will be assessed for 5 marks. Each student will have to submit 10 reports with 250 to 500 words based on the nature of the practical. They will be assessed using the following marking criteria:

- Objective - 1 mark
- Method description - 2 marks
- Results - 1 mark
- Interpretation/ conclusion - 1 mark

At the end of all the laboratory sessions, the average of scores in each laboratory report will be taken as the final score for laboratory report. This will be finalized before their laboratory exam. Template for laboratory report is given in Appendix A of the DPD.

- **Laboratory Exam (20%)**

Students will sit for a lab exam at the end of semester for a duration of 3 hours. This exam will be on practical application of the skills developed over the course of all the laboratory sessions and the theory classes.

D. Semester-end Examination: (40%)

Semester end Examination for the duration of two hours will be for 40 marks. All the units of the subject matter will be included for the examination.

Overview of Assessment Approaches

Areas of assignments		Quantity	Weighting
A. Assignment		1	15%
B. Presentation		1	15%
C. Lab	Lab Report	10	10%
	Lab Exam	1	20%
D. Semester-end Examination		1	40%

Pre-requisites: None

Subject Matter

Unit I: Survival Analysis

1.1 Functions of survival times
1.2 Survival distributions and their applications to:
  1.2.1 Exponential
  1.2.2 Gamma
  1.2.3 Weibull
  1.2.4 Rayleigh
  1.2.5 Lognormal
  1.2.6 Death density function for a distribution having bath-tub shaped hazard function
1.3 Cox proportional hazards model
1.4 Censoring Schemes:
  1.4.1 Type I censoring
  1.4.2 Type II censoring
  1.4.3 progressive or random censoring with biological examples.
  1.4.4 Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples
1.5 Non-parametric methods:
  1.5.1 Actuarial and Kaplan-Meier methods for estimating survival function
  1.5.2 Variance of the Estimator.

Unit II: Competing Risk Theory

2.1 Indices for measurement of probability of death under competing risks and their inter-relations
2.2 Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods
2.3 Theory of independent and dependent risks
2.4 Bivariate normal dependent risk model

Unit III: Stochastic Epidemic Models

4.1. Simple epidemic models
4.2. General epidemic model definition and concept

4.3. Duration of an epidemic

Unit IV: Statistical Genetics

4.1 Introduction
4.2 concepts-Genotype
4.3 Phenotype
4.4 Dominance
4.5 Recessiveness
4.6 Linkage and Recombination
4.7 Coupling and Repulsion
4.8 Mendelian laws of Heredity
4.9 Random mating
4.10 Gametic Array:
4.11 relation between genotypic array and gametic array under random mating
4.12 Distribution of genotypes under random mating
4.13 Clinical Trials:
4.13.1 Planning and design of clinical trials,
4.13.2 Phase I, II and III trials
4.14 Single Blinding

List of Laboratory Sessions

1. Estimating survival function
2. Determining death density function and hazard function
3. Identifying type of censoring and to estimate survival time for type I, type II and progressively type I censored data
4. Estimation of mean survival time and variance of the estimator for type I and type II data censored data
5. Estimation of mean survival time and variance of the estimator for progressively type I censored data
6. Estimating the survival function and variance of the estimator using Non-parametric methods with Actuarial methods and Kaplan-Meier method
7. Estimating Crude probability of death, partially crude probability of death and gene frequencies
8. Estimating Net-type I and Net-type II probability of death

Reading List

Essential Reading

Biswas, S. (2007). *Applied Stochastic Processes: [a biostatistical and population oriented approach].* Reprinted 2nd Central Edition, New Central Book Agency.

Kleinbaum, D.G. and Klein, M. (2012). *Survival Analysis* (3rd ed.). New York, Ny Springer New York.

Lee, E.T. and Wang, J.W. (2013). *Statistical Methods for Survival Data Analysis* (4th ed.). Wiley.

Additional Reading

Chiang, C.L. (1968). *Introduction to Stochastic Processes in BioStatistics* (99th ed.). John Wiley and Sons.

Indrayan, A. (2008). *Medical Biostatistics* (2nd ed.). Chapman and Hall/CRC.

Date: March, 2022

RSM414 Capstone Project

Module Code & Title: RSM414 Capstone Project
Programme: BSc in Data Science
Credit Value: 48
Module Tutor: Phub Namgay

General Objective

Students are expected to carry out a capstone project under a supervisor, which culminates in a final project report. The time frame of the project is 12 weeks. The project aims to provide a platform for students to apply knowledge and skills gained throughout the data science academic discourse on a real-world project. Moreover, it provides an avenue for students to use the theoretical foundations of the programme in a real-world case, thereby better preparing them to handle data science undertakings in a real work environment. It will also help students gather, analyse, model, interpret, and apply data analytics tools and techniques on small or big data from varied sources. The successful submission of a project report and presentation of their project is a strong indicator of data science repertoire in a student. The semester-long project is equivalent to three modules of 48 credits.

Learning Outcomes

On completion of the capstone project, students will be able to:

1. Identify a suitable topic for a project, formulate and articulate questions, hypotheses, and objectives
2. Carry out a literature search and summarise the state of the art
3. Articulate suitable methodology and professionally engage with primary or secondary data sources
4. Handle real-world data science problems and apply expertise and skills to solve a problem
5. Design and develop effective and efficient resources and methods to solve a data science problem optimally
6. Implement tools for activity in data science projects such as programming, statistics, database, and project management
7. Demonstrate proficiency in management and stewardship of data, namely developing metadata, ontologies, and data management plans (DMPs)
8. Interpret, evaluate, and communicate project results through a report, discussion, and presentation
9. Develop portable skills, especially in writing project proposals, status reports, documentation, and presentation slides

Learning and Teaching Approach:

- **Project coordinator** – Capstone Project Committee (CPC) consists of the head of department (HoD), programme leader (PL), and supervisors. The Programme's PL will serve as a capstone project coordinator and is responsible for administrative aspects of the project, such as creating a project work plan, designing templates and rubrics for proposals, and chairing presentation seminars. Towards the end of year 4, semester I, the coordinator shall convene a meeting with the CPC members to discuss the modalities of the capstone project, such as finding projects, nominating a supervisor, and other project-related activities. With support from the HoD, the coordinator will liaise with other organisations and agencies for data-science-related projects that students can take up as capstone projects. Students will also be encouraged to find projects worth working on as capstone projects. However, the

caveat is that a project should be relevant to the data science programme or related to some aspects of data. The coordinator shall present a working report to the CPC members during the autumn semester's closing meeting to ensure that the number of projects is adequate and aspects of the capstone project are in place.

- **Supervisor** – Student(s) will work under the supervision of a faculty (supervisor) nominated by the CPC. The supervisor guides the student's project and provides timely feedback on all graded and ungraded components. It is worth noting that the supervisor need not have a background or subject knowledge of the project undertaken by a student. Furthermore, the supervisor will report students' progress or related matters to the coordinator and the CPC. Students must meet their supervisor at least once a week to update work progress and resolve issues that impede project progress. The supervisor and students can internally decide on modalities to assess the project's status, such as weekly meetings and demo presentations. However, it should be consistent with other students.

Table 1. Credit breakdown for the capstone project

Type	Teaching and Learning Approaches	Hours per week	Total credit hours
Contact	Lecture	2	30
	Individual tutorial and guidance	5	75
Independent study	Writing of reports, including seminar	25	375
Total			**480**

Assessment approach

A Panel with at least four members that includes an external evaluator, preferably with a technical background, invited from another college will assess the capstone project. The student's evaluation will be 60% (240 marks) by the Panel and 40 % (160 marks) by the supervisor for a total mark of 400. As for assessment, the Panel will be involved in activities C and D of **Table *2***, whereas the supervisor will be involved in activities A, B, and E. The rationale for not involving the supervisor in activities C and D is for fresh insights and perspectives by an external evaluator to improve the project. Moreover, involving the supervisor is redundant as they are already involved across the capstone project lifecycle. The page limit and word count (including footnotes, excluding title, abstract, bibliography, and appendices) and assessment weighting for each task are given in each section. **Table *2*** encapsulates the quantity of assessment and its weight for the capstone project.

As for ethics in the project, ethical considerations will be taken seriously across all phases of the capstone project. For example, any sensitive data will be handled with the utmost care, such as using de-identification or anonymisation techniques, depending on the needs and requirements of the project. The capstone project must be conducted in line with the code of ethics and intellectual property policies of the Royal University of Bhutan. Where necessary, capstone project will consider the ethical permit and approval requirement. The College Research Committee (CRC) will be responsible for giving the ethical clearance for the project. Moreover, the project coordinator will orient students on project ethics and personal conduct through a week-long seminar (Unit I: Introduction to Capstone Project and Ethics) at the beginning of the semester. The project coordinator and supervisor are responsible for ensuring that activities are conducted following good project practices. Supervisor consent is necessary if students want to write a conference or journal paper based on the project. Moreover, students are encouraged to explore such avenues to disseminate knowledge.

A: Project proposal report: 20%

Student(s) will prepare a preliminary proposal (page limit is 10–15 pages and approximately 3500 words) and submit it to their supervisor. The supervisor will be responsible for supervisory support

and assistance while planning, designing, and drafting a project proposal. It is worth noting that the project proposal is permissible for change only before acceptance, and the change request will not be considered afterwards. As for assessment, the project proposal will be assessed for 80 marks (converted into 20% of the final mark) using the following criteria:

- Introduction: 5
- Problem description:15
- Purpose of the project: 10
- Overview of literature: 15
- Methodology and methods: 20
- Evaluation techniques: 15

Regarding the evaluation of the capstone project, evaluation techniques will constitute modalities for evaluating the project deliverables, such as algorithms, programs, and software. Students must draft a preliminary framework for assessing deliverables, such as test cases to evaluate an algorithm and program. If there is a well-established framework, students are advised to use it to avoid rework. Moreover, it enhances the validity of project deliverables.

B: Progress review: 10%

The review of project progress is crucial for timely constructive feedback and comments, thereby contributing to the project's milestones. Moreover, it assures the progression of a project according to the goals and objectives outlined in the proposal. The project will be reviewed twice—before and after the mid-semester examination. The supervisor will assess their respective student's progress reports (2–3 pages, approximately 750 words). The report will be evaluated for 40 marks (10% of the final mark) using the following criteria:

- Project status: 15
- Deliverables: 20
- Timeline and the way forward: 5

C: Project report: 40%

Student(s) must submit the final project report (two copies) to the coordinator two weeks prior to the presentation. Subsequently, the coordinator will hand over a report to the external evaluator to assess the student through a presentation and question and answer session. The page and approximate word limits are 15–25 pages and 10000-12000 words, respectively. Likewise, the project report will be assessed for 160 marks, which is equivalent to 40% of the final mark, using the following criteria (detailed rubrics in **Appendix A**):

- Introduction: 20
- Overview of literature: 25
- Methodology and methods: 40
- Results, findings, and interpretation: 40
- Metadata and DMPS: 20
- Implications of the project: 15

The report should align with the initial project proposal—that is, the introduction, literature, methodology and methods should simply be an augmented version of things mentioned in the proposal. The emphasis will be more on the last three criteria in the list. Students should comprehensively provide a detail of the analysis and synthesis of the results and findings of their project. As for interpretation, students should discuss their project's implications with industry practitioners. They also have to highlight the limitations of their projects. In order to ensure good data governance and management practices, students have to use some metadata schema, such as Dublin Core, to document and describe their project data set. Likewise, they are also advised to maintain DMPS for all the data sets throughout the project. Finally, regarding implication,

students should discuss the wider implication of their project for practitioners. The elements above will be the basis for evaluating the final project.

D: Project seminar: 20%

Student(s) will present their project to the panel. Student(s) will be given 60 minutes for presentation; the time breakdown will depend on the rubrics. The assessment rubrics will be made available to the student and supervisor prior to the presentation. The coordinator and examiner will compile the marks and be certified by the respective supervisors. The presentation will be assessed for 80 marks, which is equivalent to 20% of the final mark, using the following criteria (detailed rubrics in **Appendix A**):

- Organisation and coherence: 20
- Understanding and clarity of the subject matter: 25
- Central idea of the capstone project: 20
- Question and answer sessions: 15

E: Monthly progress meeting: 10%

A student should maintain a project diary that records each activity from inception to completion. Additionally, the project diary should be submitted separately to their supervisor. Supervisors could use the diary as a reference to assess individual students' learning and progress. The meeting will be evaluated for 40 marks, which is 10% of the final mark, using the following criteria:

- Project diary: 15
- Question and answer session: 15
- Way forward of the project: 10

Table 2. An overview of the assessment approaches and weighting

Areas of assessment	Quantity	Weighting	Assessor	
			Panel	Supervisor
A. Project proposal report	1	20%		✓
B. Progress review	2	10%		✓
C. Project report	1	40%	✓	
D. Project seminar	1	20%	✓	
E. Monthly progress meeting	4	10%		✓

Pre-requisites: RSM301 Research Methods

Subject Matter:

Unit 1: Introduction to Capstone Project and Ethics

1.1 Capstone project
    1.1.1 Writing proposal and final report
1.2 Literature review
    1.2.1 Planning and organising literature review
1.3 Project scheduling
    1.3.1 Project activity schedule using project management tools
1.4 Metadata and Data Management Plans (DMPs)
1.5 Data collection approaches and techniques
    1.5.1 Data privacy
    1.5.2 Data protection acts

1.5.3 General data protection regulation (GDPR)
1.5.4 Commercial confidentiality
1.6 Ethics in the capstone project

Unit 2: Project proposal report and References

2.1 Introduction
2.1.1 Brief overview of the project topic
2.1.2 Goals of the project
2.1.3 Scope of the project
2.2 Purpose
2.2.1 Statement of the purpose
2.3 Problem description
2.3.1 Elaborate on the problem statement
2.3.2 Nature of the problem
2.3.2.1 Rationale for believing the problem exists
2.3.3 Describe how the project will address the problem
2.3.4 Limitations of the project
2.4 Literature review
2.4.1 Theoretical justification of the project
2.4.2 Process, validity, and value of the project
2.5 Methodology
2.5.1 Potential methods and techniques
2.5.2 Gathering data/materials
2.5.3 Ethical consideration
2.5.4 Project activity timeline and tools
2.5.4.1 Gantt chart
2.6 Evaluation
2.6.1 Specific expected outcomes
2.6.2 Measurable expected outcomes

Unit III: Project Report

3.1 Introduction
3.1.1 Problem statement
3.1.2 Significance of the study
3.1.3 Scope statement
3.1.4 Project timeline
3.1.4.1 Tools to render project timeline visually
3.1.5 Feasibility study
3.1.5.1 Assessment of the practicality or viability of the project
3.2 Literature review
3.2.1.1 Strengths, weakness, and opportunities
3.3 Methodology
3.3.1 Methods used to provide structure and cohesiveness
3.3.1.1 Workflow from inception to completion
3.3.2 Subject or participants of the project
3.3.3 Data collection approaches and strategies
3.3.3.1 Advantage, limitation, and ethical issues
3.3.4 Data analysis approaches and software
3.3.4.1 Coding method, analysis of interviews/recordings
3.3.4.2 Statistical analysis
3.4 Results, findings, and discussions
3.5 Metadata and Data Management Plans (DMPs)

3.5.1 Information concerning how data and materials are collected, organised, and stored
3.5.2 Findability, accessibility, interoperability, and reusability (FAIR) of the project data
3.6 Implications, recommendations, and applications

Refer to Appendix A for the final report structure.

Unit IV: Project Seminar

4.1. Oral presentation of the capstone project
4.1.1. Aims and objectives of the project
4.1.2. Organisation and coherence of the presentation
4.1.3. Understanding and clarity of the subject matter
4.1.4. Central idea of the capstone project

Reading List:

Essential Reading List

Hauhart, R. C., & Grahe, J. E. (2015). *Designing and teaching undergraduate capstone courses*. San Francisco: Jossey-Bass.

Hoffman, H. F. (2014). *Engineering Capstone Course: fundamentals for students and instructors.* Cham: Springer.

Additional Reading List

Grix, J. (2004). *The foundations of research. New York:* Palgrave Macmillan.

Strunk, W., & White, E. B. 1. (2000). *The elements of style*. 4th ed. New York: Longman.

Date: April 2021

Appendix A: General Guideline and Template for Capstone Project

1. Introduction

The following guideline is designed to provide a framework for the capstone project of students in data science. The guideline outlines the clear roles and responsibilities of project coordinator, supervisors, students, and external evaluators. The guideline will be used to ensure that all aspects of the capstone project are completed to a high standard, with clear expectations for each category and criteria for assessment. By adhering to the guideline, students can ensure that their capstone project is a comprehensive and insightful piece of work, while supervisors and external evaluators can use the criteria to assess and provide feedback on the project in a consistent and fair manner. Overall, this guideline aims to provide a clear and effective framework for the successful completion and assessment of the capstone project in data science.

2. Roles and Responsibilities

The following are the roles and responsibilities of the students, supervisors, external evaluators, the CPC, the Project Coordinator.

a. CPC:

i. Nominate supervisors for projects.
ii. Identify members for the Panel to evaluate the projects, including an external evaluator.
iii. Ensure that ethical consideration are taken seriously across all phases of the capstone project.

iv. Chiefly responsible for all logistical arrangements of capstone project.

b. Project Coordinator:

i. Responsible for administrative aspects of the project, such as creating a project work plan, designing templates and rubrics for proposals, and chairing presentation seminars.
ii. Convene a meeting with the CPC members to discuss the modalities of the capstone project, such as finding projects, nominating a supervisor, and other project-related activities.
iii. Present a working report to the CPC members during the autumn semester's closing meeting to ensure that the number of projects is adequate and aspects of the capstone project are in place.
iv. Make arrangement for orientation of students on project ethics and personal conduct through a week-long seminar at the beginning of the semester.
v. Hand over final reports to the external evaluator(s).

c. Supervisor:

i. Guide the student's project and provide timely feedback on all graded and ungraded components.
ii. Report students' progress or related matters to the coordinator and the CPC.
iii. Meet with their student at least once a week to review work progress and address any issues.
iv. Collaborate with the student to determine modalities to assess the project's status, such as weekly meetings and demo presentations.
v. Ensure that the student's work is consistent with other students in the program, even if the supervisor does not have a background or subject knowledge of the project undertaken by the student.
vi. Ensure that students have access to necessary resources and tools.

d. Student:

i. Identify a real-world problem and develop a proposal for the project.
ii. Get ethical clearance for the project from the CRC.
iii. Conduct research and collect relevant data.
iv. Work on the capstone project under the supervision of a faculty (supervisor) nominated by the CPC.
v. Meet with their supervisor at least once a week to update work progress and resolve issues that impede project progress.
vi. Submit graded and ungraded components of the project to their supervisor in a timely manner.
vii. Collaborate with the supervisor to determine modalities to assess the project's status, such as weekly meetings and demo presentations.
viii. Analyze the results and draw conclusions.
ix. Prepare a final report and submit final report (two copies) to the PC at least two weeks before the presentation.
x. Present their project to the Panel.

xi. Explore avenues to disseminate knowledge by writing a conference or journal paper based on the project.

e. External Evaluator(s):

i. Review the final report and presentation.
ii. Provide feedback and suggestions to students.
iii. Evaluate the project based on the criteria provided.

3. Template for Project Diary

The following template could be used by the student for maintaining project diary for monthly progress meeting with the supervisor.

Date	Activity	Time Spent	Progress Made	Challenges Encountered	Solution/Next Steps

4. Marking Criteria for Project Report

The following marking rubrics will be used for evaluating the project report.

Criteria	Outstanding (5)	Very Good (4)	Good (3)	Satisfactory (2)	Fail (1)
Introduction (20)	Clearly states the problem and its significance, with a comprehensive explanation of the project's goals and objectives.	Clearly states the problem and its significance, with a well-developed explanation of the project's goals and objectives.	Clearly states the problem and its significance, with a satisfactory explanation of the project's goals and objectives.	States the problem and its significance, but with some lack of clarity or focus on the project's goals and objectives.	Fails to state the problem and its significance, or with significant deficiencies in explanation of the project's goals and objectives.
Score: Comments:					
Overview of Literature (25)	Presents a thorough and insightful review of relevant literature, with strong evidence of critical analysis and synthesis.	Presents a comprehensive review of relevant literature, with good evidence of critical analysis and synthesis.	Presents a satisfactory review of relevant literature, with reasonable evidence of critical analysis and synthesis.	Presents a satisfactory review of relevant literature, with reasonable evidence of critical analysis and synthesis.	Presents a basic review of relevant literature, but with some gaps in critical analysis and synthesis.
Score: Comments:					
Methodology and Methods (40)	Describes the methodology and methods with exceptional clarity and precision, demonstrating a high level of expertise and mastery.	Describes the methodology and methods with good clarity and precision, demonstrating a strong level of expertise and mastery.	Describes the methodology and methods with acceptable clarity and precision, demonstrating a reasonable level of	Describes the methodology and methods with some lack of clarity or precision, demonstrating a basic level of expertise and mastery.	Fails to describe the methodology and methods, or presents them with significant deficiencies in clarity, precision, or expertise.

			expertise and mastery.		
Score: Comments:					
Results, Findings, and Interpretation (40)	Presents the results and findings with exceptional clarity and coherence, with insightful and comprehensive interpretation.	Presents the results and findings with good clarity and coherence, with insightful interpretation.	Presents the results and findings with acceptable clarity and coherence, with reasonable interpretation.	Presents the results and findings with some lack of clarity or coherence, with basic interpretation.	Presents the results and findings with significant deficiencies in clarity, coherence, or interpretation.
Score: Comments:					
Metadata and Data Management Plans (20)	Demonstrates an exceptional level of expertise and care in metadata and data management, with comprehensive and effective plans.	Demonstrates a strong level of expertise and care in metadata and data management, with effective plans.	Demonstrates a reasonable level of expertise and care in metadata and data management, with satisfactory plans.	Demonstrates a basic level of expertise and care in metadata and data management, with some gaps in plans.	Demonstrates significant deficiencies in expertise and care in metadata and data management, or presents plans that are inadequate or non-existent.
Score: Comments:					
Implications of the Project (15)	Presents comprehensive and insightful implications of the project, with clear and compelling recommendations	Presents strong implications of the project, with well-supported recommendations for future research or practical applications.	Presents reasonable implications of the project, with some support for recommendations for future research or practical applications.	Presents basic implications of the project, but with some gaps in support for recommendations for future research or practical applications.	Presents inadequate or non-existent implications of the project, or with significant deficiencies in

	for future research or practical applications.				support for recommendations for future research or practical applications.
Score: Comments:					

To calculate the score for a given criterion, the formula can be used:

Score = (Weightage for the criterion X Category Achieved) / 5

For instance, if a student's **Introduction** is rated as "**Very Good**", their score is: *(20 x 4) / 5 = 16*

This formula is also applicable for determining the scores for Project Seminar.

5. Marking Criteria for Project Seminar

The following marking rubrics will be used for assessing presentation during Project Seminar.

Criteria	Outstanding (5)	Very Good (4)	Good (3)	Satisfactory (2)	Fail (1)
Organization and coherence (20)	The presentation is exceptionally well-organized, coherent, and easy to follow. Transitions between sections are seamless.	The presentation is well-organized and coherent. Transitions between sections are generally smooth.	The presentation is mostly well-organized and coherent, but some sections may lack clarity or coherence. Transitions between sections are sometimes abrupt.	The presentation is somewhat disorganized and lacks coherence. Transitions between sections are frequently abrupt.	The presentation is poorly organized and lacks coherence. Transitions between sections are often unclear.
Score: Comments:					
Understanding and clarity of the subject matter (25)	The presenter demonstrates an exceptional understanding of the subject matter and presents it with exceptional clarity.	The presenter demonstrates a very good understanding of the subject matter and presents it with very good clarity.	The presenter demonstrates a good understanding of the subject matter and presents it with good clarity.	The presenter demonstrates a satisfactory understanding of the subject matter and presents it with satisfactory clarity.	The presenter demonstrates a poor understanding of the subject matter and presents it with poor clarity.
Score: Comments:					
Central idea of the capstone project (20)	The central idea of the capstone project is exceptionally clear and is effectively conveyed throughout the presentation.	The central idea of the capstone project is very clear and is effectively conveyed throughout the presentation.	The central idea of the capstone project is mostly clear and is conveyed throughout the presentation.	The central idea of the capstone project is somewhat unclear and is conveyed inconsistently throughout the presentation.	The central idea of the capstone project is unclear and is not effectively conveyed throughout the presentation.

Score: Comments:					
Question and answer sessions (15)	The presenter handles questions and answers exceptionally well, providing detailed and insightful responses.	The presenter handles questions and answers very well, providing detailed and insightful responses.	The presenter handles questions and answers generally well, but some responses may lack detail or insight.	The presenter handles questions and answers somewhat poorly, providing incomplete or unclear responses.	The presenter handles questions and answers poorly, providing incomplete or unclear responses.
Score: Comments:					

General template for the Capstone Project

1. Title page - required, not numbered
   1.1. Title of the project
   1.2. Name of the candidates (alphabetical order)
   1.3. Name and designation of the supervisor
   1.4. Degree for which the project is submitted
   1.5. Name of the college
   1.6. Month and year the project is presented
   1.7. Declaration of the student and supervisor
2. Preliminary pages
   2.1. Signature page - not numbered. Pages following it are numbered using lowercase Roman numerals
   2.2. Table of Contents - required
   2.3. List of tables - if needed
   2.4. List of figures - if needed
   2.5. Glossary: if needed
   2.6. List of abbreviations - if needed
   2.7. Acknowledgement
3. Abstract - required, 300 words
4. Main text
   4.1. Introduction
   4.2. Purpose statement
   4.3. Description of problem
   4.4. Literature review
   4.5. Methodology
   4.6. Data collection, analysis and results interpretation
   4.7. Conclusions, recommendations and summary
   4.8. References - Required (15 sources of different types, preferably authoritative documents)
5. Appendices: if needed. Pagination follows the last References page
   5.1. Questionnaire and interview schedule (optional)
   5.2. Observation schedule (optional)
   5.3. Coding frame (optional)
   5.4. Letters sent to sample members (optional)
   5.5. Any other
6. Length of the Project Report
   6.1. Report - 15–25 pages
   6.2. Text style - APA format
   6.3. Alignment - Justify
   6.4. Font - Times New Roman
   6.5. Font size - 12
   6.6. Line spacing - 1.5

Essential Reading List

Hauhart, R. C., & Grahe, J. E. (2015). Designing and teaching undergraduate capstone courses. San Francisco: Jossey-Bass.

Hoffman, Harvey. F. (2014). Engineering Capstone Course: fundamentals for students and instructors. Cham: Springer.

Suggested Reading List

Grix, J. (2004). *The foundations of research*. New York: Palgrave Macmillan.Strunk, W., & White, E. B. 1. (2000). The elements of style. 4th ed. New York: Longman.

Appendix B: Library Resources

Essential Readings

Module Code & Title	Author/Title/Publisher	Price (Nu.)	In Stock	Additional copies needed	Total Cost (Nu)	Acquire by
Year 1 Sem I						
DST101: Descriptive Statistics	Freund, J. E. (2008). *Mathematical Statistics*, Prentice Hall, New Delhi.		10	0	0	
	Goon, A. M., Gupta, M. K., and Dasgupta, B. (1991): *Fundamentals of Statistics*, Vol. I and II, World Press, Calcutta.		18	0	0	
	Linneman, T. J. (2021). *Social Statistics Managing Data, Conducting Analyses, Presenting Results*. Taylor and Francis Group.	14650	0	3	43950	Spring, 2021
	Gupta, S. P. (2002): *Statistical Methods*, Sultan Chand and Sons, New Delhi.	695	8	10(procured)	1390	Spring, 2021
ALG107: Set Theory and Theory of Equations	Arumugam. S & Issac. A. T. (2015). *Modern Algebra.* Chennai: Scitech Publications (India) Pvt. Ltd.	3567.45	0	4 (supply order placed)	14269.8	Spring, 2021
	Manickavachagom Pillai. T. K. & Natarajan. S. (2009). Algebra I. Chennai: Viswanathan Printers and Publishers.		5	0	0	
ACS101: Academic Skills	American Psychological Association. (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.		20	0	0	
	Department of Academic Affairs. (2018). *Students' materials for academic skills*. Thimphu: Royal University of Bhutan.		15	0	0	

	Department of Academic Affairs. (2018). *Tutors' materials for academic skills*. Thimphu: Royal University of Bhutan.		25	0	0	
CAL111: Calculus	Kreyszig, E. (2006). *Advanced Engineering Mathematics*. (8thedition). John Wiley and Sons.		20	0	0	
	Thomas, G.B and Finney, R.L. (2012). *Calculus and Analytic Geometry* (12th ed.) New Delhi: Dorling Kindersly (India) Pvt. Ltd.		24	0	0	
	Salas, S.L., Hille, E. & Etgen, G.J. (2003). *Calculus: One and Several Variables*. (9th edition). John Wiley and Sons.		5	0	0	
PLT102: Programming in Python	VanderPlas, J. (2016). *Python Data Science Handbook*. OReilly	1250	0	10 (procured)	12500	Spring,2021
	Heinold, B. (2012). *A Practical Introduction to Python Programming.* Creative Commons Attribution-Noncommercial-Share Alike 3.0 Unported License	2199.65	0	4(supply order placed)	8798.6	Spring,2021
Year 1 Sem II						
DST102: Probability Theory	Capinski, M., and Zastawniah (2001). *Probability Through Problems*, Springer, New Delhi.	3729.38	0	4(supply order placed)	14917.52	Autumn, 2021
	Robert, A. B. (2000). *Probability and Measure Theory*, Academic Press, New Delhi.	5226.86	0	5 (procured)	20907.47	Autumn, 2021
	Rohatgi, V. K., and Ehsan, S. (2015). *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Private Ltd., New Delhi.	931.45	0	4(supply order placed)	3725.8	Autumn, 2021
CAL206: Differential Equations I	Kreyszig, E. (2011). *Advanced Engineering Mathematics*. (10th edition). New Delhi: John Wiley & Sons.	1069	10	10(procured)	10690	Autumn, 2021
	Raisinghania, M. D. (2005). *Ordinary and Partial Differential Equations*. (8th edition).	699	3	5(procured)	3495	Autumn, 2021

	New Delhi: S. Chand & Company Private Limited.					
	Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2017). Introduction to algorithms.		23	0	0	
ALG108: Matrix Analysis and Vector Spaces	Anton. H. & Rorres. C. (2005). *Elementary Linear Algebra* (9 ed.). USA: John Wiley & Sons.	969	0	10 (procured)	9690	Autumn, 2021
Year 2 Sem I						
PLT203 R Programming for Data Analysis	Crawley, M.J. (2012). *The R book*. John Whiley & Sons.	6059	0	3	18177	Spring, 2022
	Matloff, N. (2011). *The Art of R programming: A tour of statistical software design*. No Starch Press.	2454	0	3	7362	Spring, 2022
DST203: Probability Distributions I	Hogg, R. V., and Craig, A. T. (1995). *Introduction to Mathematical Statistics,* Prentice-Hall, New Delhi.		10	0	0	
	Mood, A. M., Graybill, F. A., and Boes, D. C. (1991). *Introduction to Theory of Statistics,* Cambridge University Press, New Delhi.		20	0	0	
AMT209 Mathematical Logic	Cormen, T. H., Leiserson, C. E., & Rivest., R. L. (2001). *Introduction to Algorithms* (2nd ed). New Delhi: Prentice-Hall India.		21	0	0	
	Liu, C.L. (2000). *Elements of Discrete Mathematics* (2nd ed.). New Delhi: McGraw-Hill.		48	0	0	
	Rosen, K.H. (2007). *Discrete Mathematics and its Applications* (6th ed.). New Delhi: Tata McGraw Hill.		9	1(procured)		Spring, 2022

	Tremblay, J.P., & Manohar, R. (2007). *Discrete Mathematical Structures with Applications to Computer Science*. New Delhi: Tata McGraw Hill.		40	0	0	
CAE201 Database Systems	Elmasri, R., & Navathe, S. (2011). *Fundamentals of Database Systems*. Addison Wesley.		17	0	0	
	Silberschatz, A., Korth, H. F., & Sudarshan, S. (2010). DatabaseSystem Concepts.	1025	0	5(procured)	5125	Spring, 2022
Year 2 Sem II						
DST204 Probability Distributions II	Agresti, A. (2002). *Categorical Data Analysis*, John Wiley, New Delhi.	409	0	4	1636	Autumn, 2022
	David, H. A., and Nagaraja, H. N. (2003). *Order Statistics*, John Wiley, New Delhi.	10295	0	4	41180	Autumn, 2022
	Johnson, N. L., Kotz, S., and Balakrishnan, N. (2000). *Continuous Univariate Distributions*, John Wiley, New Delhi.	1465	0	4	5860	Autumn, 2022
IST201 Sampling Theory	Cassel, C. M., Sarndal, C. E., and Wretman, J. H. (1977). *Foundations of Inference in Survey Sampling*, John Wiley, New Delhi.	2768.21	0	4	11072.84	Autumn, 2022
	Chaudhari, A., and Stenger, H. (2005). *Survey Sampling Theory and Methods*, Chapman and Hall, New Delhi.	275	0	4	1100	Autumn, 2022
	Chaudhari, A., and Voss, J. W. E. (1988). *Unified Theory and Strategies of Survey Sampling*, North Holland, New Delhi.	2674	0	4	10696	Autumn, 2022
	Cochran, W. G. (1977). *Sampling Techniques*, John Wiley, New Delhi.	1153.56	0	4	4614.26	Autumn, 2022

	Murthy, M. N. (1977). *Sampling Theory and Methods*, Statistical Publishing Society, Kolkatta.	3276.55	0	4	13106.2	Autumn, 2022
AMT210: Numerical Methods	Balagurusamy, E. (2014): *Numerical Methods*. McGrew Hill Education (India) Private Limited.		5	0	0	
	Sastry, S.S.(2000): *Introductory Methods of Numerical Analysis*. Asoke K. Ghosh, Prentice-Hall of India Private Limited		4	0	0	
	Gerald, C.F. & Wheatley, P.O.(2013): *Applied Numerical Analysis*. Dorling Kindersley (India) Pvt. Ltd.		5	0	0	
ANY204 Real Analysis	Malik, S.C. *Principles of Real Analysis.* New Delhi: New Age International pvt ltd	399	10	5(procured)	1995	Spring, 2022
	Robert G. Bartle & Donald R. Sherbert.(2007). *Introduction to Real Analysis.* (3rd ed.).New Delhi: Willey India Private Limited.		9	0	0	
	Apostol, M.T.(2005). *Calculus-Volume I.*(2nd ed.) New Delhi: New Age International Private Limited.		10	0	0	
Year 3 Sem I						
IST302 Regression analysis	Bapat, R. B. (1993). *Linear Algebra and Linear Models*, Springer-Verlag, New Delhi.	3869	0	4	15476	Spring, 2023
	Barnett, V., and Lewis, T. (1984). *Outliers in Statistical Data*, John Wiley, New Delhi.	11822	0	4	47288	Spring, 2023
	Belsley, D. A., Kuh, E., and Welsch, R. E. (2004). *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*, John Wiley, New Delhi.	8311.4	0	4	33245.6	Spring, 2023

	Draper, N. R., and Smith, H. (1998). *Applied Regression Analysis*, John Wiley, New Delhi.	11822	0	4	47288	Spring, 2023
	Kleinbaum, D. G., and Kupper, L. L. (2014). *Applied Regression analysis and other Multivariate Methods*, Duxbury Press, Massachusetts, USA.			4		Spring, 2023
IST303 Statistical Inference	Casela, G., and Berger, R. L. (2001). *Statistical Inference*, Duxbury Thompson Learning, New Delhi.	9897.7	0	4	39590.8	Spring, 2023
	Christensen, R. (1990). *Log Linear Models*, Springer, New Delhi.	5648.8	0	4	22595.2	Spring, 2023
	Conover, W. J. (1980). *Practical Non-parametric Statistics*, John Wiley, New Delhi.	5485	0	4	21940	Spring, 2023
IST304 Nonparametric and Sequential methods	L. Lehmann: Nonparametrics: Statistical Methods Based on Ranks.	1568	0	4	6272	Spring, 2023
	L. Wasserman: All of Nonparametric Statistics.	6444	0	4	25776	Spring, 2023
	R. H. Randles and D. A. Wolfe: Introduction to the Theory of Nonparametric Statistics.	5519	0	4	22076	Spring, 2023
RSM301: Research Methods	Bhattacherjee, A. (2012) *Social science research: Principles, methods, and practices*. Published under the Creative Commons Attribution-	767	0	3	2301	Spring, 2023
	Bryman, A. (2016). *Social research methods*. Oxford university press.		11	0	0	
	Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.	1150	0	3	3450	Spring, 2023
	Kumar, R. (2019). *Research methodology: A step-by-step*		10	0	0	

	guide for beginners. Sage Publications Limited.					
Year 3 Sem II						
IST306 Multivariate Analysis	Anderson, T. W. (1984). *An Introduction to Multivariate Statistical Analysis*, John Wiley, New Delhi	1609	0	4	6436	Autumn, 2023
	Johnson, R. A., and Wichern, D. W. (1988). *Applied Multivariate Statistical Analysis*, Prentice Hall, New Delhi.	3865	0	4	15460	Autumn, 2023
	Rencher, A. C. (2002). *Methods of Multivariate Analysis*, John Wiley, New Delhi.	1458	0	4	5832	Autumn, 2023
IST305 Statistical Quality Control	E. L. Grant & R. S. Leavenworth: *Statistical Quality Control*, McGraw-Hill, N. Y.	1860	0	4	7440	Autumn, 2023
	D. C. Montgomery: *Introduction to Statistical Quality Control*, Wiley, N. Y.	1105	0	4	4420	Autumn, 2023
AMT311: Introduction to Operation Research	Taha. H. A. (2013). *Operations research: an introduction*. (9thed.). Pearson Education India.		20	0	0	
	Hillier. F. S. (2021). *Introduction to operations research*. (11thed.). Tata McGraw-Hill Education.		20	0	0	
AMT312: Stochastic processes	Ross, S. (2008). *Stochastic Processes* (2 ed.). Wiley		3	0	0	
	Bhat, B. R. (2000). *Stochastic Models*: *Analysis and Applications*, New Age International, New Delhi.	374	0	4	1496	Autumn, 2023
	Medhi, J. (2001). *Stochastic Processes*, Wiley Eastern Ltd., New Delhi.	4241	1	4	16964	Autumn, 2023
Year 4 Sem I						
MQM405	Gujarati, D. N. (2004). *Basic Econometrics*, Tata McGraw Hill, New Delhi.		15	0	0	

Econometrics	Wooldridge,J.M.(2006). *Introductory Econometrics: A Modern Approach*, Cengage Learning, Ohio.		10	0	0	
	Greene, W. H. (2007). *Econometric Analysis*, Prentice Hall, New Jersey.	4371	0	3	13116	Spring, 2024
	Koop, G. (2007). *Introduction to Econometrics*, John Wiley, New Delhi.	4679	0	3	14037	Spring, 2024
IST409 Forecasting techniques and statistical modelling	Box, G. E. P., Jenkins, G. M., and Reinsel, G. C. (1994). *Time Series Analysis: Forecasting and Control*, Pearson Education, New Delhi.	2788	0	4	11152	Spring, 2024
	Hyndman, R. J., & Athanasopoulos, G. (2013). *Forecasting: Principles and Practice*, OTexts: Melbourne	4525	0	3	13575	Spring, 2024
	Metcalfe, A. V. & Cowpertwait P. S. P. (2009). *Introductory Time Series with R*, Springer, New Delhi.	3375	0	3	10125	Spring, 2024
	Tsay, R. S. (2010). *Analysis of Financial Time-series*, Wiley, New Delhi.	14727	0	3	44181	Spring, 2024
	Makridakis, S., Wheelwright, S.C., and Hyndman, R. J. (1998). *Forecasting: Methods and Applications*, John Wiley, New Delhi.	4271	0	4	17084	Spring, 2024
IST408 Design of Experiments	Jones, B., & Montgomery, D. C. (2019). *Design of Experiments: A Modern Approach*, Wiley, New Jersey.	11736	0	3	35208	Spring, 2024
	Dean, A. M., and Voss, D. (1999). *Design and Analysis of Experiments*, Springer, New Delhi.	8178.9	0	4	327 15.6	Spring, 2024
	Dey, A. (1986). *Theory of Block Designs*, Wiley Eastern Ltd., New Delhi.	2891.76	0	4	11567.04	Spring, 2024

	Lawson, J. (2015). *Design and Analysis of Experiments with R,* CRC Press, Florida.	7534	0	3	22602	Spring, 2024
	Morris, M. (2011). *Design of Experiments: An introduction based on linear models,* CRC Press, Florida.	6903	0	3	20709	Spring, 2024
AST407 Mathematical Demography and Actuarial Statistics	Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.	1453	0	4	5812	Spring, 2024
	Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.		8	0	0	
Year 4 Sem II						
IST410 Survival Analysis and Biostatistics	Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.	8066	0	4	32264	Autumn, 2024
	Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.	1422	0	4	5688	Autumn, 2024
	Kleinbaum, D.G. (1996): Survival Analysis, Springer.	8711	0	4	34844	Autumn, 2024
RSM412 Capstone Project	Bemker, M., & Schreiner, B. (Eds.). (2016). The DNP degree & capstone project: A practical guide. DEStech Publications, Inc.	5369	0	3	16107	Autumn, 2024
	Hauhart, R. C., & Grahe, J. E. (2015). Designing and teaching undergraduate capstone courses. San Francisco: Jossey-Bass.	2688	0	3	8064	Autumn, 2024
	Hoffman, Harvey. F. (2014). Engineering Capstone Course:	909	0	3	2727	Autumn, 2024

	fundamentals for students and instructors. Cham: Springer.					
DSC201 Machine Learning	Albon, C. (2018). *Machine learning with python cookbook: Practical solutions from preprocessing to deep learning.* " O'Reilly Media, Inc.".	3835	0	3	11505	Autumn, 2024
	Coelho, L. P., & Richert, W. (2015). *Building machine learning systems with Python.* Packt Publishing Ltd.	1687	0	3	5061	Autumn, 2024
	Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J. (2005). *Data mining: practical machine learning tools and techniques (Morgan-Kaufman Series of Data Management Systems).*	838	0	3	2514	Autumn, 2024

Additional Reading

Module Code & Title	**Author/Title/Publisher**	**Price (Nu.)**	**In Stock**	**Additional copies needed**	**Total Cost (Nu)**	**Acquire by**
Year 1 Sem I						
DST101: Descriptive Statistics	Gupta, S.C., and Kapoor, V.K. (2020). *Fundamentals of Mathematical Statistics*, Sultan Chand and Sons, New Delhi.	590	0	4 (procured)	2360	Spring, 2021
	Gupta, S. C., and Kapoor, V. K. (2007). *Applied Statistics*, Sultan Chand and Sons, New Delhi.	590	0	1	590	Spring, 2021
	Walpole, R. E., Myers, R. H., Myers S. L., and Ye, K. (2001). *Probability and Statistics for Engineers and Computer*		8	0	0	

	Scientists, Prentice Hall, New Delhi.					
ALG107: Set Theory and Theory of Equations	Rosen, K. (2011). Discrete Mathematics and Its Applications (7th ed.). New York: McGraw-Hill Science/Engineering/Math.	895	5	1(procured)	895	Spring, 2021
	Singal, M.K. & Singal, A.R. (2006). Mathematics for Physical Sciences. New Delhi: R. Chand & Co.		4	0	0	
ACS101 Academic Skills	Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). Abingdon, Oxford: Routledge.		15	0	0	
	Butler, L. (2007). *Fundamentals of academic writing*. New York, NY: Pearson Longman.		4	0	0	
	Gillet, A. (2013, January 15). *UEFAP (Using English for academic purposes): A guide for students in higher education.* Retrieved from http://www.uefap.com					
	Gillet, A., Hammond, A., & Martala, M. (2009). *Inside track successful academic writing.* England: Pearson Education.		4	0	0	
	Hogue, A. (2007). *First steps in academic writing*. New York: Pearson Education ESL.		5	0	0	
	Oshima, A., & Hogue, A. (2005). *Writing academic English* (4th ed.). White Plains, NY: Pearson Education.		10	0	0	
	Oshima, A., & Hogue, A. (2006). *Introduction to academic writing* (3rd ed.). New York: Pearson Longman.		6	0	0	
	Ramsey-Fowler, H., & Aaron, J. E. (2010). *The little brown handbook* (11th ed.). New York, NY: Pearson Longman.		5	0	0	
CAL111: Calculus	Apostal, T.M. (2005). *Calculus: Volume I*. John Wiley and Sons.		12	0	0	
	Spiegel, M.R. (1981). *Advanced Calculus*. (Schaum's Outline		2	0	0	

	Series, Asian Student Edition). McGraw Hill Book Company.					
	Frank, A. Jr., & Mendelson, E. (1992). *Differential and Integral Calculus*. (Schaum's Outline series, 3rd edition). McGraw Hill Book Company.		11	0	0	
	Steward, J. (1999). *Calculus* (4th ed.) Singapore: Brooks/Cole Publishing Company		1	0	0	
PLT102: Programming in Python	Lutz, M. (2013). *Learning Python* (5th ed.). OReilly.	1600	0	2(procured)	3200	Spring, 2021
	Sedgewick, R., Wayne, K., & Dondero, R. (2015). *Introduction to programming in Python: An interdisciplinary approach*. Addison-Wesley.	4444	0	1	4444	Spring, 2021
	Rao, R. N. (2017). *Core python programming*. Dreamtech press.	699	0	2 (procured)	1398	Spring, 2021
Year 1 Sem II						
DST102: Probability Theory	Dudewicz, E. J., and Mishra, S. N. (1988). *Modern Mathematical Statistics*, John Wiley, New Delhi.	969.53	0	1	969.53	Autumn, 2021
	Devore, J. L., & Berk, K. N. (2012). *Modern mathematical statistics with applications*, Springer, New York.	4408	0	1	4408	Autumn, 2021
CAL206: Differential Equations I	Shepley L. Ross. (2007). *Differential Equations*. (3rd edition). Singapore: John Wiley & Sons.		4	0	0	
	Wylie. C R. (1985). *Differential Equations*. New Delhi: McGraw Hill		2	0	0	
	Coddington, E A. (1988). *Introduction to Ordinary Differential Equations.* New Delhi: Prentice Hall India.		1	0	0	

ADS101 Data Structures and Algorithms	Sedgewick, R., Wayne, K. (2011). *Algorithms*, 4th Edition.. Addison-Wesley.		5	0	0	
ALG108: Matrix Analysis and Vector Spaces	Hoffman, K., & Kunze, R. (2006). *Linear Algebra* (2nd ed.) New Delhi: Dorly Kindersly (India) Pvt. Ltd.		4	0	0	
	Kolman, B., & Hill, D.R. (2006). *Introduction to Linear Algebra with applications* (7th ed.) New Delhi: Dorly Kindersly (India) Pvt. Ltd.		9	0	0	
	Cohen, A.M, Cuypers, H., & Sterk, H. (1999). *Algebra Interactive*. New York: Springer Verlag Inc.	851	0	2	1702	Autumn, 2021
	Kreyszig, E. (2005). *Advanced Engineering Mathematics* (8 ed.) Singapore: John Whiley & Sons (Asia) Pvt. Ltd.		10	0	0	
Year 2 Sem I						
PLT203 R Programming for Data Analysis	Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York	3687.5	0	2(procured)	7375	Spring, 2022
	Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.	0	3	0	0	
DST203: Probability Distributions I	Hoel, P. G. (1971). *Introduction to Mathematical Statistics,* John Wiley, New Delhi.	290	0	2	580	Spring, 2022
	Goon, A. M., Gupta, M. K., and Dasgupta, R. (1986). *Outline of Statistics,* Vol. I. World Press, Calcutta.		5	0	0	
AMT209 Mathematical Logic	Fletcher, N.R. (1985). *Discrete Structures: an introduction to mathematics for computer science*. New Jersey: Prentice-Hall Inc.					

	Kolman, B., Busby, R, C., & Ross, S. (1996). *Discrete Mathematical Structures*. (3rd ed.). New Jersey: Prentice-Hall Inc.	750	0	2(procured)	1500	Spring, 2022
	Lipschutz, S., & Lipson., M (2001). *2000 Solved Problems in Discrete Mathematics. (*2nd ed). New Delhi: TMH.					
CAE201 Database Systems	Ramakrishnan, R., & Gehrke, J. (2003). Database Management Systems. McGraw Hill	310	0	1	310	Spring, 2022
	Deitel, P., & Deitel, H. (2007). *Internet & world wide web: how to program*. Prentice Hall Press.	1050	0	1(procured)	1050	Spring, 2022
Year 2 Sem II						
DST204 Probability Distributions II	Arnold, B. C., Balakrishnan, N., and Nagaraja, H. N. (1992). *A First Course in Order Statistics*, John Wiley, New Delhi.	4143	0	1	4143	Autumn, 2022
	Rao, C.,R. (1965). *Linear Statistical Inference and its Applications*, John Wiley, New Delhi.	852	0	1	852	Autumn, 2022
	Rohatgi, V. K., and Saleh, A. K. Md. E. (2005). *An Introduction to Probability and Statistics*, John Wiley, New Delhi.		6	0	0	
	Searle, S. R. (1996). *Linear Models*, Academic Press, New Delhi	93	0	1	93	Autumn, 2022
IST201 Sampling Theory	Hansen, M. H., Hurwitz, W. H., and Madow, W. G. (1993). *Sample Survey Methods and Theory*, Vol. I and Vol. II., John Wiley, New Delhi.	71	0	1	71	Autumn, 2022
	Hedayat, A. S., and Sinha, B. K. (1991). *Design and Inference in Finite Population Sampling*, John Wiley, New Delhi.	560	0	1	560	Autumn, 2022
	Singh, D., and Chaudhary, F. S. (2002). *Theory and Analysis of Sample Survey Designs*, New Age International Pvt. Ltd., New Delhi.	275	0	1(procured)	275	Spring, 2022

	Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., and Asok, C. (1984). *Sampling Theory of Surveys with Applications*, Indian Society of Agricultural Statistics, New Delhi.	361	0	1	361	Autumn, 2022
	Thompson, S. K. (2000). *Sampling*, John Wiley, New Delhi	308	0	1	308	Autumn, 2022
AMT210: Numerical Methods	Prasad, D. (2012): *An Introduction to Numerical Analysis*. Narosa Publishing House Pvt. Ltd.		5	0	0	
	Atkinson, K.E. An Introduction to Numerical Analysis. John Wiley &Sons.2nd editions		14	0	0	
	Burden, R.L. & Faires, J.D: *Numerical Analysis.* Brooks/Cole Publishing Company, Ninth Edition		3	0	0	
ANY204 Real Analysis	Rudin, W. *Principles of Mathematical Analysis.* New York: McGraw-Hill		10	0	0	
	Royden, H.L.(1988). *Real Analysis*.(3rd ed.). London:Collier-Macmillan International		10	0	0	
	Apostol, M.T.(1997).*Mathematical Analysis*. New Delhi: Narosa Publishing House		10	0	0	
	Narayan, S.(1998). A module of Mathematical Analysis.(12th revised ed.). New Delhi: S. Chand & Company	4328	0	1	4328	Autumn, 2022
Year 3 Sem I						
IST302 Regression analysis	Graybill, F. A. (1976). *Theory and Application of the Linear Model*, Duxbury, North Scituate, USA	289	0	1	289	Spring, 2023
	Joshi, D. D. (1987). *Linear Estimation and Design of Experiments*, Wiley Eastern, New Delhi.	310	0	1	310	Spring, 2023
	Kleinbaum, D. G., and Kupper, L. L. (1978). *Applied Regression analysis and other Multivariate Methods*, Duxbury Press, Massachusetts, USA.	236	0	1	236	Spring, 2023

	Montgomery, D. C., Peck, E., and Vining, G. (2003). *Introduction to Linear Regression Analysis*, John Wiley, New Delhi.	290	0	2	580	Spring, 2023
	Searle, S. R. (1998). *Variance Components*, John Wiley, New Delhi.	3890	0	1	3890	Spring, 2023
	Sheffe, H. (1999). *Analysis of Variance*, John Wiley, New Delhi.	12015	0	1	12015	Spring, 2023
IST303 Statistical Inference	Box, G .E. P., and Tiao, G. C. (1973). *Bayesian Inference in Statistical Analysis*, Addison Wesely, New Delhi.	980	0	1	980	Spring, 2023
	Wald, A. (2004). *Sequential Analysis*, Dover Publications, New Delhi.	352	0	1	352	Spring, 2023
IST304 Nonparametric and Sequential methods	M. Hollander and D. A. Wolfe: Nonparametric Statistical Methods.	290	0	1	290	Spring, 2023
	R. H. Randles and D. A. Wolfe: Introduction to the Theory of Nonparametric Statistics	418	0	1	418	Spring, 2023
RSM301: Research Methods	Wolf, H. K. and Pant, P. R. (2002). *Social Science Research and Thesis Writing*. Kathmandu: Buddha Academic.	0	5	0	0	
	Punch, K. F. (2005). *Introduction to Social research: Qualitative and Quantitative Approaches*. London: Sage Publication.	0	5	0	0	
	Ghosh, B. N. (2007). *Scientific Method and Social Research* (Revised edition). New Delhi: Sterling Publishers Pvt. Ltd.	0	5	0	0	
	Cozby, P. C. (2001). *Methods in Behavioural Research* (seventh edition). Mayfield Publishing Co.	0	5	0	0	
	Kumar, R. (2005). *Research Methodology: A Step By Step Guide for Beginners, (Second edition)*	0	6	0	0	
Year 3 Sem II						

IST306 Multivariate Analysis	Chatfield, C., & Collins, A. J. (1982). *Introduction to Multivariate Analysis*, Prentice Hall, New Delhi.			1		Autumn, 2023
	Srivastava, M. S., and Khatri, C. G. (1979). *An Introduction to Multivariate Statistics*, North Holland, New Delhi.	1065	0	1	1065	Autumn, 2023
IST305 Statistical Quality Control	Tebbutt, T. H. Y. (2013). Principles of water quality control. Elsevier.			1		Autumn, 2023
	Evans, J. R., & Lindsay, W. M. (2002). The management and control of quality (Vol. 5, pp. 115-128). Cincinnati, OH: South-western.					
	Besterfield, D. H. (2004). Quality control. Pearson Education India.		0	1		Autumn, 2023
AMT311: Introduction to Operation Research	Bernard W. Taylor III. (1993). *Introduction to Management Sciences*. (4thed.). New York: Allyn and Bacon.			1		Autumn, 2023
	Kanti Swarup, Manmohan & Gupta. (2018). *Operations Research*. (10thed.). New Delhi: Sultan Chand and Sons Publishing Co.			1		Autumn, 2023
	Manmohan & Gupta P.K. (1987). *Operations Research and Statistical Analysis*. (3rded.). New Delhi: Sultan Chand and Sons Publishers.			1		Autumn, 2023
AMT312: Stochastic processes	Adke, S. R., and Manjunath, S. M. (1984). *An Introduction to Finite Markov Processes*, John Wiley, New Delhi.	1308	0	1	1308	Autumn, 2023
	Bailey, N. T. J. (1964). *Elements of Stochastic Processes with Applications to the Natural Sciences*, Wiley Eastern Ltd., New Delhi.	422	0	1	422	Autumn, 2023
Year 4 Sem I						
MQM405	Maddala, G. S. (2001). *Introduction to Econometrics*, John Wiley, New Delhi.	0	4	0	0	

Econometrics	Pindyck, R. S., and Rubinfeld, D. L. (1998). *Econometric Models and Economic Forecasts*, McGraw Hill, New Delhi.	309	0	1	309	Spring, 2024
	Verbeek, M. (2008). *A Guide to Modern Econometrics*, John Wiley, New Delhi.	2790	0	1	2790	Spring, 2024
IST409 Forecasting techniques and statistical modelling	Seber, G. A. F., and Wild, C. J. (1989). *Nonlinear Regression*, John Wiley, New Delhi	1507	0	1	1507	Spring, 2024
	Brockwell, P. J., and Davis, R. A. (1996). *Introduction to Time Series and Forecasting*, Springer Verlag, New Delhi.					
	Ratkowsky, D. A. (1990). *Handbook of Nonlinear Regression Models*, Marcel Dekker, London.	3902	0	1	3902	Spring, 2024
IST408 Design of Experiments	Cochran, W. G., & Cox, G. M. (1992). *Experimental Designs*, John Wiley, New Delhi					
	Hinkelmann, K., and Kempthorne, O. (1994). *Design and Analysis of Experiments*, John Wiley, New Delhi.	284	0	1	284	Spring, 2024
	Fisher, R.A. (1971). *Design and Analysis of Experiments*, Oliver and Boyd, Edinburg.	1467	0	1	1467	Spring, 2024
AST407 Mathematical Demography and Actuarial Statistics	Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.	252	0	1	252	Spring, 2024
	Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.	3396	0	1	3396	Spring, 2024
	Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New York.	309	0	1	309	Spring, 2024
Year 4 Sem II						
IST410 Survival Analysis and	Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.	310	0	1	310	Autumn, 2024
	Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.	788	0	1	788	Autumn, 2024

Biostatistics						
RSM412 Capstone Project	Grix, J., (2004). *The foundations of Research*. London: Palgrave Macmillan		6	0	0	
	Strunk, W., & White, E. B. 1. (2000). The elements of style. 4th ed. New York: Longman.			1		Autumn, 2024
DSC201 Machine Learning	Bowles, M. (2015). *Machine learning in Python: essential techniques for predictive analysis. John Wiley & Sons.*			1		Autumn, 2024
	Garreta, R., & Moncecchi, G. (2013). *Learning scikit-learn: machine learning in python.* Packt Publishing Ltd.			1		Autumn, 2024