Study Guide

Linear Programming 171 & 181

Academic Year 2024

"Research **Young people must take it upon themselves to ensure that they receive the highest education possible so that they can represent us well in future as future leaders."**

Nelson Mandela

Academic Year 2024

Version 2.0 (April 2024)

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MODULE DESCRIPTION	
Module Name	Linear Programming
Module Code	LPR 181 & LPR 171
Qualification	Bachelor of Computing (B. Compt)
Module NQF Level	5
Duration (weeks)	3
Pre-requisites	MAT181

MODULE DESCRIPTION	
Module Name	Linear Programming
Module Code	LPR 171
Qualification	Bachelor of Information Technology (BIT)
Module NQF Level	5
Duration (weeks)	3
Pre-requisites	MAT171

OUTCOMES

Purpose

Linear Programming is a scientific approach to decision-making that seeks to best design and operate systems under specific conditions requiring the allocation of scarce resources. It is an interdisciplinary mathematical science that focuses on the effective use of technology by organisations. In contrast, many other science and engineering disciplines focus on technology, considering its secondary uses.

Outcomes

Upon successful completion of this module, the student will be able to:

- Demonstrate an informed understanding of linear programming of one or more fields, disciplines or practices, and an informed understanding of the key terms, concepts, facts, general principles, rules and theories of that field, discipline, or practice.
- Show an awareness of how knowledge or a knowledge system develops and evolves within linear programming.
- Select and apply standard formulations, algorithms, or solutions within linear programming and plan and manage an implementation process within a well-defined, familiar, supported environment.
- Identify, evaluate, and solve defined, routine and new problems within a familiar context and apply solutions based on relevant evidence and procedures or other forms of explanation appropriate to linear programming, demonstrating an understanding of the consequences.
- Gather information from a range of sources, including oral, written, or symbolic texts, to select information appropriate to the task and to apply basic processes of analysis, synthesis and evaluation of that information.

- Operate in a range of familiar and new contexts, demonstrating an understanding of different kinds of systems, their constituent parts, and the relationships between these parts, and understand how actions in one area impact other areas within the same system.

STUDENT SUPPORT

Please contact your lecturer for subject-related support. The lecturers presenting this subject are:

- M. Chruku - Chiruka.M@belgiumcampus.ac.za
- S. Makweche - makweche.s@belgiumcampus.ac.za
- J. Blignaut- blignaut.j@belgiumcampus.ac.za
- S. Laubscher - Schoeman.s@belgiumcampus.ac.za
- M. Combrinck - combrinck.m@belgiumcampus.ac.za
- E. Rynners - rynners.e@belgiumcampus.ac.za
- E. Cheteni – Cheteni.e@belgiumcampus.ac.za

If the lecturers were unable to assist, you can also contact the cluster head for this subject:

- C. P. Tavagwisa – tavagwisa.p@belgiumcampus.ac.za

Further student support services are available via the counsellors:

- Lethlabile L. Selamolela – selamolela.l@belgiumcampus.ac.za
- Mathapelo Leshilo – leshilo.m@belgiumcampus.ac.za
- Alisha Blom - Narine.a@belgiumcampus.ac.za

ASSESSMENT PLAN			
ASSIGNMENTS/PROJECTS			
Assignment 1 weight:	10	Assignment 1 due date:	2024/05/05
Assignment 2 weight:	10	Assignment 2 due date:	2024/05/12
Assignment 3 weight:	10	Assignment 3 due date:	2024/05/19
TESTS			
Test 1 weight:	20	Test 1 date:	2024/05/06
Test 2 weight:	20	Test 2 date:	2024/05/13
Test 3 weight:	30	Test 3 date:	2024/05/20?????? Career day on 17th May

STUDENT RESOURCES Which resources will be used during this module?	
PRESCRIBED MATERIAL	
Textbook 1	
Prasad, D. (2015). *Operation Research*. Alpha Science Information Limited: India, Ghaziabad.	
Location (Library / URL / PDF)	Ebscohost Operations Research: EBSCOhost
RECOMMENDED MATERIAL	
Textbook 2	
Winston, W. 2004. *Operations research applications and algorithms.* 4ed. Brooks Cole – Thomson Learning: Belmont, CA.	
Location (Library / URL / PDF)	Ebscohost Operations Research: EBSCOhost
RECOMMENDED READING	
Dantzig, G. B. (2002). Linear programming. *Operations Research,* 50(1): 42-47.	
Wolsey, L. (2021). *Integer Programming.* 2ed. John Wiley & Sons: Hoboken, NJ.	
STUDENT MATERIAL	
Item	**Location**
Content on Moodle	The relevant Moodle course
PowerPoint slides	Distributed to students via Moodle
Exercises / Activities	Dispersed throughout the course on Moodle.
TECHNOLOGY (HARDWARE OR SOFTWARE) REQUIRED	
Software/Hardware	**Details e.g. version to be used (either minimum or required version)**
Microsoft Office, Excel	

LESSON PLAN OUTLINE	
Date	**Specific outcomes (SO) to be covered / Class Activity / Assessment**
29-04-2024	SO1: Introduction to Linear Programming SO2: Maximisation Linear Programming Models
30-04-2024	SO3: Graphical Solutions with minimisation Linear Programming Models
01-05-2024	Public holiday
02-05-2024	SO3: Graphical Solutions with minimisation Linear Programming Models
03-05-2024	SO4: Microsoft Excel Solver
05-05-2024	*Assignment 1 due*
06-05-2024	**Class Test 1**
07-05-2024	SO5: Diet Linear Programming Models SO6: Work Scheduling Linear Programming Models
08-05-2024	SO6: Work Scheduling Linear Programming Models SO7: Primal Simplex Algorithm (intro to simplex algorithms)
09-05-2024	SO7: Primal Simplex Algorithm (intro to simplex algorithms)
10-05-2024	**BC Graduation Ceremony**
12-05-2024	*Assignment 2 due*
13-05-2024	**Class Test 2**
14-05-2024	SO8: Two-Phase Simplex Algorithm
15-05-2024	SO9: Degeneracy
16-05-2024	SO10: Unrestricted Signs Week 3 exercises as homework (Mock test in Word format)
20-05-2024?	**Summative Test** ????????????????????
17-05-2024	**Career day**
19-05-2024	*Assignment 3 due*

OUTCOME BREAKDOWN

Specific Outcome 1: Introduction to Linear Programming

- Define Operations research and how.
- Define a system.
- Define a mathematical model.
- Explain the process of building a model.
- Discuss a few problem examples that are addressed with operations research.

Specific Outcome 2: Maximisation Linear Programming Models

- Discuss what a formulated Linear Programming Model (LP model) consist of.
- Santa's workshop example with above elements.
- Explain the different linear programming assumptions with Santa's workshop.
- Explain how to test the feasible region and what are the different types of solutions.

Specific Outcome 3: Graphical Solutions with minimisation Linear Programming Models

- Graphing linear inequalities.
- Graphically plot all constraints.
- Determine feasible area.
- Determine the most optimal solution.
- Go through the formulation of Korean auto to show a basic minimisation LP model.
- Binding constraints.
- Convex sets.
- Extreme points (another way of finding optimal point).
- Special cases when solving graphically.

Specific Outcome 4: Microsoft Excel Solver

- How to add Solver on Excel.
- Solver with Santa's workshop (show what to do if it is a min. problem).
- Special cases when using Solver.

Specific Outcome 5: Diet Linear Programming Models

- Introduction to Diet problems.
- Freshman diet example.
- More realistic diets.

Specific Outcome 6: Work Scheduling Linear Programming Models

- Introduction to work scheduling problems.
- Example post office Version 1 (full time, no overtime employees).
- Other examples should first be given as exercises before explaining.
- Using Excel Solver and applying rounding to non-integer decision values to meet constraints at the most optimal objective value.
- Creating a fair schedule for the base employee (employee 1).
- Creating a fair schedule for any employee.
- Modelling issues.
- Real-world applications.

Specific Outcome 7: Primal Simplex Algorithm (intro to simplex algorithms)

- Introduction to algorithms.
- Simplex algorithms and different types tough throughout the different LPR courses.
- Primal simplex introduction & conditions (Santa's workshop).
- Canonical form - Example with Santa's workshop.
- Primal simplex algorithm step by step (Excel can be used, but this is to understand the calculations. At least one row, pivot row and ratio test should be shown).
    - Initial Tableau.
    - Optimality check.
    - Interpreting each table with Basic and non-basic variables.
    - Pivot operations.
    - Interpreting solution.
- Primal simplex algorithm using Excel.

  - Initial Tableau.
  - Optimality check.
  - Interpreting each table with Basic and non-basic variables.
  - Pivot operations.
  - Interpreting solution.
- Graphing the primal simplex algorithm.
- Special cases using primal simplex (unique, alternative and unbounded)

Specific Outcome 8: Two-Phase Simplex Algorithm

- Two-phase simplex introduction & conditions (Farmer brown).
- Canonical form - Example with Farmer brown.
- Two-phase simplex algorithm using Excel.
  - Initial Tableau.
  - 1st phase
  - Optimality check.
  - Interpreting each table with Basic and non-basic variables.
  - Pivot operations.
  - 2nd phase
  - Optimality check.
  - Interpreting each table with Basic and non-basic variables.
  - Pivot operations.
  - Interpreting solution.
- Graphing the two-phase simplex algorithm.
- Special cases using two-phase simplex (unique, alternative, infeasible and unbounded)

Specific Outcome 9: Degeneracy

- Introduction to degeneracy.
- Non-degenerate vs degenerate.
- Cycling.
- Efficiency of the Simplex Algorithm for Degenerate LPs

Specific Outcome 10: Unrestricted Signs

- Introduction to URS.
- Formulation.
- Solve graphically.
- Solve using Solver.
- Conditions and canonical form for simplex algorithms (example is primal simplex).
- Let them solve.
- Interpret solution.