Algorithms Assignments

Due: as assigned prior to the start of class

Assumption: Students are responsible for reading and following directions, for the contents of rubrics, and to request clarification if needed. Requests to change deadlines must made in advance (no last minute requests will be considered).

Objective: since copying the steps of an algorithm is not an effective use of our limited time in class and since understanding the steps of an algorithm requires more than one reading, you will perform these steps individually, which will allow us to focus on application during class

Assignment: Using the textbook, prepare the following for each algorithm:

- using a bulleted format, write the steps of the algorithm in your own words - rote copying of the algorithm from the book or another source is not acceptable (it does not help you understand the algorithm)
- identify the specific pieces of information that will be given in the problem which will clue you in that this is the correct algorithm, generally to include the following as appropriate:
  - variable characteristics (discrete/continuous, scalar/vector)
  - characteristics/formulation of the constraints
  - nature/formulation of the objective function
- bring your completed work to class - your professor/neighbor will review it before class starts

Requirements:

- a paper copy of your work is to be shown to the instructor (or classmate as instructed) before class; the format is at your discretion, but it should be intentional not haphazard
- this is an individual assignment; you may not copy from each other or show each other your work; however, you may discuss the algorithm with each other and ask each other specific questions about the problems/algorithms (but you must write your own versions)
- use of AI/online resources should be used sparingly and with care since it will likely undermine the purpose of the assignment

Failure to complete an algorithms assignment will constitute a failure to be prepared for class, and you will be asked to leave (this will count as a personal absence). Productive professional meetings require that participants prepare as necessary prior to the start of the meeting. This requirement will help you build important professional skills.

Optimization with Spreadsheets - 45 points

Due: January 24, 2025

Objective: develop the skill to efficiently and professionally set up an optimization problem in Excel with the goal of being able to share/print the page and clearly communicate the problem and the solution; develop skills that will be helpful in solving the case study problems

Assignment: Work the following problems from Chapter 21: 21-1, 21-4, 21-5

Upload a pdf for each problem (to represent the "printed" report of your solution) and a single Excel file (with each problem presented/solved on a separate tab) to the Canvas assignment.

You will be graded on the accuracy of your answer as well as the professionalism and clarity of your presentation in the Excel file as well as the "printouts." (Pay attention to how your pages "print.")

This is an individual assignment. You may not copy from each other or show someone your working solution. However, you may discuss the problems with each other and ask someone specific questions about the problems or the Excel solver. We will use the CpS 110 guidelines for giving help - you may ask someone to help you debug, but you must do all the typing/clicking on your solution. You should cite the help that you received (who and how they helped you).

Solutions are provided by the professor in Canvas for homework problems from future chapters to help students develop understanding as part of their personal study and may be used at the students' discretion. However, solutions for graded assignments (including these problems) are not to be referenced. You are always welcome to bring questions to your professor or ask in class.

Multicriteria Optimization Assignment - 35 points

Due: April 28, 2025

Present all work professionally (handwritten portions are acceptable). Lack of professional presentation will generate a penalty.

Consider

$$\min \left[f_1(x) = e^x,\ f_2(x) = \begin{cases} \frac{1}{1+x} & x < 5 \\ (x-5)^2 + \frac{1}{6} & x \geq 5 \end{cases} \right]$$

$$\text{subject to } \ 0 \leq x \leq 10,\ x \in \mathbb{R}$$

(this biobjective optimization problem is adapted from problem 2.11 in *Multicriteria Optimization* by Matthias Ehrgott, 2^{nd} Edition, 2005, Springer)

1. Write $f_2(x)$ as a single expression that can be entered into Excel. You will need to use an indicator function, denoted $1_A(x) = \begin{cases} 1 & \text{if } x \in A \\ 0 & \text{else} \end{cases}$.

   $$f_2(x) = \left(\frac{1}{1+x}\right) 1_{x<5}(x) + \left((x-5)^2 + \frac{1}{6}\right) 1_{x \geq 5}$$

   You may want to consider the use of the `if` function in Excel.

2. Construct the Pareto curve (in the objective space).

3. Graphically identify all the non-dominated points.

4. Based on your graphs, find he set of all efficient solutions.

5. Use the definition of properly efficient (in Kuhn and Tucker's sense) to determine if this problem has properly efficient points

6. Using the theorem for Kuhn-Tucker, compute all properly efficient points including the corresponding λ and μ.

7. Formulate the weighted sum scalarization problem. Solve your formulation using the weights,

   $$w_1 = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 03.8, 0.9, 1 \quad \text{and} \quad w_2 = 1 - w_1$$

   (use Excel's nonlinear solver for each single-objective problem). Graph the Pareto curve of your 10 solutions.

8. Formulate both of the ϵ-constraint method problems for solving the biobjective problem where both f_1 and f_2 are relaxed. Solve your formulations using

   $$\epsilon = (0.01, 0.01), (0.5, 0.1), (1, 0.2), (10, 0.5), (100, 1), (1000, 5), \text{ and } (25000, 30)$$

   (use Excel's nonlinear solver for each single-objective problem - you should have 14 problems to solve). Graph the Pareto curve of your 10 solutions.

Case Studies - 150 points each

Ch 9, 10, or 21 Case Study*	Due: February 17, 2025
Ch 12, 13, or 21 Case Study*	Due: March 21, 2025
Ch 20 Case Study	Due: April 16, 2025

* only one Ch 21 Case Study can be completed
a second case study from Ch 21 will earn a 0%

Assumption: Students are responsible for reading and following directions, for the contents of rubrics, and to request clarification if needed. Requests to change deadlines must made in advance (no last minute requests will be considered).

Objective: To improve your ability to take a problem from start to finish, to develop your technical/-computation skills, and to improve your technical/professional writing skills. It is my goal that with each case study you write and read you will mature in your ability to communicate problems and their solutions to people who need that information. In light of this goal, it would be reasonable to assume that grading on your communication will become less forgiving with each case study.

Audience: These case studies will have two audiences that you must address. The first is the mathematically savvy, therefore you must include sufficient mathematical detail to convince them that your problem formulation and solution are correct (material to support this may be included in appendices). The second audience is the appropriate administrative or business manager, therefore you must include descriptive paragraphs that summarize the problem being solved, explain what your solution is, and discuss how they should use it in non-technical language.

Assignment: Chose one of the case study options listed below from the indicated chapters. Selecting an alternate case study without the professor's approval will result in a substantial penalty for failure to follow directions.

Case studies not available in your textbook are available on the course website.

- 21.1 Prudent Provision for Pensions *
- 9.1 Shipping Wood to Market
  (use sensitivity analysis for the last portion)
- 10.1 Money in Motion *
- 10.2 Aiding Allies
- 12.2 Assigning Art
- 13.1 Savvy Stock Selection *
- 13.2 International Investments *
- 20.3 Planning Planers
- 20.4 Pricing under Pressure *

* good for those interested in actuarial topics

Each project will require you to complete the same stages, 1) problem investigation, development, and formulation, 2) solution development/execution, and 3) writing the report (plan on this taking at least 30% of your time investment for the project and will be worth 40% of the grade).

Each Case Study's grade will be based on effective communication (both English/grammar/writing and in the math), accuracy of your model and solution, clarity of the presentation of the problem and the proposed solution based on the following rubric.

Case Study Rubric:

Be sure that each written submission includes enough information for your professor to evaluate almost all of the following directly from the written report. Your professor will not reverse engineer work not clearly expressed. It is highly recommended that students pay attention to the grading rubric while completing the assignment

Remember that solutions for graded assignments (including case studies) are not to be referenced.

Problem Formulation and Development (35%)

_____/10% Variable definitions - variables are correct decisions that need to be made and are explicitly defined

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/25% Mathematical model formulation - correctly **and efficiently** captures and articulates relationships to solve the problem (equations are clearly expressed)

Omitted — Inadequate/Incomplete — Acceptable — Good

Solution (25%)

_____/ 5% Correctness - presented numerical solution is correct (incorrect formulation will likely lose credit)

Omitted — Incorrect — Close — Correct

_____/20% Code/solution file – well organized/commented, neatly presented, successfully runs and produces output presented in the report, etc.

Omitted — Inadequate/Incomplete — Acceptable — Good

Communication (40%)

_____/ 5% Executive summary – clearly and concisely written stand-alone summary that is appropriate for someone who reads nothing else

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/ 5% Problem statement – clearly defines the problem and its business context (should include an introduction)

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/ 5% Presentation of variables/models - clearly defined and well integrated into document with sufficient commentary

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/10% Interpretation of model results – relates the results of the modeling process to the problem statement

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/10% Audience – sections tailored to the audience as described in the project statement

Omitted — Inadequate/Incomplete — Acceptable — Good

_____/ 5% Clarity - overall communication was clear and easy to follow (contained all information needed to understand)

Omitted — Inadequate/Incomplete — Acceptable — Good

Penalty (0%)

_____/ 0% Overall presentation - the report and solution files are professionally presented

_____/ 0% Inappropriate usage of English, failure to follow directions, submitted late (15%, 25%, 35%, 45%), etc.

_____/ 0% Use of figures/tables/equations – clearly constructed, labeled (use table/figure captions and just numbering for equations), and discussed/referenced

No figure/table/equation should be presented without commentary focusing the reader on how they can understand/interpret what they will see in the figure/table/equation (so commentary should start before the figure/etc. is presented and explicitly reference it).