Writing About Operations Research – The Introduction

1 The introduction section

- A OR project report typically contains the following sections:

0. Abstract
1. Introduction
2. Data
4. Model
5. Results
6. Recommendations and Limitations

- The purpose of the **introduction** is to give your reader the big picture of your project:
  - What is your project about?
  - What analysis did you conduct?
  - Why is it important or interesting?

- Here is a suggested outline for an introduction:
  1. **Background and motivation.** (1-3 paragraphs)
     - Start by providing some background information on your project.
     - Discuss the general project topic – assume the reader knows nothing about it.
     - Convince the reader that your project is interesting or important.
  2. **Problem description and methodology.** (1 paragraph)
     - Briefly describe your decision or prediction problem.
       - Describe the system you are studying and the data involved.
       - Describe what you want to find out about the system you are studying.
     - Give a short overview of how you propose to solve your problem.
       - Describe what kind of model you are using to solve your problem.
       - Describe how you will use the model and data to generate results and recommendations.

- If appropriate, include **citations** to relevant background information (e.g., facts and figures) and similar previous studies.
  - See Section 3 on page 5 for guidance on how to format your citations and references.

- Writing the introduction (and all the other sections) is an iterative process.
  - You probably won't get your introduction right the first time around.
  - Your problem description and methodology will probably evolve as you work on your project.
  - This is natural! You can always go back and revise it.
  - Experienced researchers and analysts do this all the time.

Example. Introduction, slightly edited, from

> S. J. Ward (Class of 2017), J. Foraker, N. A. Uhan. Resilient course and instructor scheduling in the Mathematics Department at the United States Naval Academy. *Military Operations Research* 23(3): 21-46, 2018.

Introduction

Colleges and universities continually face the problem of constructing a schedule for courses, instructors, and students that respects various constraints and objectives such as room availability, curriculum conflicts, and the preferences of students and faculty. Such *university timetabling* problems have been widely studied for the past several decades, beginning as early as 1969 (Thornley, 1969). Due to the size of many academic departments and the number of potentially conflicting objectives and constraints that must be considered, university timetabling is a task ideally suited for operations research techniques.

Creating schedules for courses and instructors at the United States Naval Academy (USNA), the undergraduate college of the United States Navy, has some interesting challenges. One such challenge is the uncertainty of available manpower: an instructor may or may not be able to teach in the upcoming semester. This happens often with USNA's military officer instructors, whose start and end dates at USNA are sometimes uncertain for a variety of reasons, such as extended deployments and sudden reassignments (e.g., individual augmentation). The availability of instructors, both civilian and military, is also affected by events such as long-term illnesses and family crises.

At USNA, the course and instructor schedule for the next semester is published near the end of the previous semester. Students (i.e., midshipmen) register for their courses around the same time. Unfortunately, disruptions to the published schedule, such as the sudden loss of an instructor, can occur between registration and the start of the next semester. However, in most cases, a course cannot simply be canceled if the instructor is no longer available to teach. Through an act of Congress, the academic program at USNA is 47 months (8 semesters) of study, and no more (United States Naval Academy, 2016). This fixed length program requires USNA to put the highest priority on ensuring students get their required classes. This involves, among many things, adjusting the course and instructor schedule. When a disruption occurs, the schedule must change to guarantee that students can take the courses they need to meet their graduation requirements on time. Generally speaking, course offerings are handled at the department level. This means that even a minor disruption can cause widespread changes to an existing schedule, creating a trickle-down effect that requires significant effort across multiple departments to address. As a result, having a timetable that is *resilient* – one that requires a minimum number of changes in the face of disruption – is an important consideration.

In this work, we study the problem of scheduling the courses and instructors in the Mathematics Department at USNA in a resilient manner. Every semester, the department needs to schedule around 70 instructors and 150-180 course sections into 30 class periods and 30 rooms. To model the discrete choices involved in scheduling and the random nature of disruptions, we formulate a stochastic integer linear program that schedules these courses, instructors, and rooms. In addition to maximizing instructor preferences and minimizing the number of rooms assigned to instructors, this stochastic integer linear program minimizes the expected number of changes required in the schedule if a disruption were to occur, given a subjective probability distribution over a finite set of possible disruption scenarios. We run our model on a number of instances derived from actual data from the past three years, and investigate the effect of emphasizing different parts of the objective function on the running time and resulting schedules.

2 An exercise in technical writing

In this exercise, we will discuss the standards in the written report section of the grading rubric in the course policy statement. The goal is to help you write mindfully and create a better report in the long run. Let's consider the following paragraph.

> The Nimitz Library houses the Nimitz Coffee Bar, a popular coffee shop on campus, where students can get a variety of drinks and snacks during the day between classes and at night while they are studying. Students at the Naval Academy love coffee! But lately, they have been super frustrated by how long it takes to get coffee at Nimitz coffee bar. One cause of the long waiting times is that Nimitz Coffee Bar currently has a staffing shortage. The delay in service is frequently causing them to be late to class. In addition to the staffing shortage, students believe that the current system is inefficient and a reallocation of duties could improve the number of busy servers and customer service. We develop a simulation of Nimitz Coffee Bar to determine the optimal staffing levels.

For each written report standards below, determine if the paragraph is Exemplary, Satisfactory, Developing, or Unsatisfactory, and note how you would improve the current paragraph.

Grammar, spelling, punctuation

Organization

Clarity

Completeness

Tone

Technical language

As a class, let's rewrite the paragraph.

2.1 Tips for writing and rewriting

- When you have a thought, write it down. The sentence doesn't have to be perfect the first time around. It's easier to rewrite something that is written down than construct the perfect sentence.
- When working to rewrite a paragraph, it may be easiest to work from the original paragraph and rewrite sentence by sentence.
- After you write a paragraph, pull out the rubric and grade your own work. This will help you see what parts of your writing are clear and where you can improve.

3 APA citation and reference style

- There is no standard style for citations and references in the operations research literature.
- For this course, we will use the APA (American Psychological Association) style, which is similar to what many operations research journals use.
- Below, you'll find examples of common types of in-text citations and references.
- You can find a much more detailed guide on APA in-text citations and the reference list here: https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/index.html
- Use the citations tool in Google Docs: Tools > Citations

In-text citations

Summary or paraphrase. Include the author's last name and the date either in a signal phrase or in parentheses at the end.

> Saltzman (2009) asserts that integer programming significantly reduces the amount of time spent constructing what is to be considered a good, feasible schedule.
>
> The scheduling process often begins well in advance due to university planning requirements (Waterer 1995).

A work with two authors. Name both authors in the signal phrase or parentheses each time you cite the work. In the parentheses, use "&" between the authors' names; in the signal phrase, use "and."

> For example, Chen and Zhang (2009) discussed how to modify their allocation of expected cost into an allocation of realized cost.
>
> Another difficult, but common and beneficial set of constraints consistently implemented in more recent formulations is referred to as "room stability" (Lach & Lübbecke 2008).

A work with three to five authors. Identify all authors in the signal phrase or the parentheses the first time you cite the source.

> In particular, Kranich, Perea, and Peters (2005) studied the strong sequential core of a dynamic cooperative game, which we adapt to the setting we study here.

In subsequent citations, use the first author's name followed by "et al." in either the signal phrase or the parentheses.

> This set of constraints requires multi-period courses to be taught in consecutive periods and has been known to make the problem NP-hard (Daskalaki et al. 2004).

A work with six or more authors. Use only the first author's name followed by "et al." in all citations.

Reference list

General guidelines.

- Put your reference list in a separate section titled "References."
- Your references should be listed in alphabetical order, based on the first author's last name.
- Italicize titles and subtitles of books. Capitalize only the first word of the title and subtitle, as well as all proper nouns.
- Capitalize only the first word of the title and subtitle of articles.

- For each entry in your reference list, indent every line after the first line. This is called **hanging indentation**.
- Only include references you cite in your report. Do not include other references, even if you have read them.

Article in a journal paginated by volume.

Bertsimas, D. & Brown, D. B. (2009). Constructing uncertainty sets for robust linear optimization. *Operations Research, 57*, 1483-1495.

Article in a journal paginated by issue.

Martin, C. H. (2004). Ohio University's College of Business uses integer programming to schedule classes. *Interfaces, 34*(6), 460-465.

Conference proceedings.

Edmonds, J. (1970). Submodular functions, matroids, and certain polyhedra. In R. Guy, H. Hanani, N. Sauer, & J. Schönheim (Eds.), *Combinatorial Structures and Their Applications (Calgary International Conference on Combinatorial Structures and Their Applications)* (pp. 442-454). New York, NY: Gordon and Breach.

Government document.

United States Naval Academy. (2016). *Academic Dean and Provost Notice 5420.1: Periodic Program Review/Visiting Committee Additional Information*. Annapolis, MD: Author.

Report from a private organization.

American Psychiatric Association. (2000). *Practice guidelines for the treatment of patients with eating disorders* (2nd ed.). Washington, DC: Author.

Book.

Grötschel, M., Lovász, L., & Schrijver, A. (1993). *Geometric algorithms and combinatorial optimization.* Berlin: Springer.

References

Hacker, D. (1995). *A writer's reference.* (3rd ed.). New York: St. Martin's.

Purdue Online Writing Lab. (n.d.) *APA Style Workshop*. Purdue Online Writing Lab. https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/index.html