APS111 & APS113 Engineering Strategies and Practice

Instructors: Susan McCahan, Ted Nolan, Ben Kinsella, Chirag Variawa and Patricia Sheridan

Final Examination

MULTIPLE CHOICE BOOKLET – Booklet 1

December 09, 2022

6:30 pm – 9:00 pm (2.5 hours)

- This is a 2.5 hour final exam with 44 questions (34 Multiple Choice and 10 Long Answer). The multiple choice questions are worth 50% of the exam grade and the long answer are worth 50% of the exam grade.
- This is a Type A closed book examination; no aids permitted other than a paper translation-only dictionary (i.e. direct word-to-word translations; no definitions.)
- If you need scrap paper for draft work, ask an invigilator.
- Ensure that you have **THREE** items:
    1. **MULTIPLE CHOICE BOOKLET – Booklet 1**: Contains all the multiple choice questions. **DO NOT** record answers in Booklet 1. Instead fill in the answers to the multiple choice questions on the bubble page found in the ANSWER BOOKLET – Booklet 2. Booklet 1 is **NOT** handed in and the answers will **NOT** be graded.
    2. **ANSWER BOOKLET – Booklet 2**: has all the long answer questions, space to directly answer the long answer questions, and a bubble page to record the answers to the multiple choice questions. The answers to the long answer questions should be recorded directly into **Booklet 2**. Answers to the multiple choice questions should be recorded into the bubble page in **Booklet 2**. Booklet 2 **MUST BE** handed in at the end of the exam.
    3. **CASE STUDY BOOKLET – Booklet 3:** has three case studies. Case Study #1 and #2 are to be used to answer some of the multiple choice questions. Case study #3 is used to answer the long answer questions. **Booklet 3** is **NOT** handed in at the end of the exam.
- **THIS BOOKLET IS THE MULTIPLE CHOICE BOOKLET – Booklet 1.**

Multiple-Choice (50%):

- There are a total of 34 multiple choice questions worth a total of 34 marks. These multiple choice questions are worth 50% of the exam.
- **Input your answers to the multiple choice questions on the bubble page in the Answer Booklet – Booklet 2.** Do **NOT** answer the multiple choice questions on the questions directly in this booklet. They will not be graded.
- There is no penalty for incorrect answers.
- Use a pencil or a pen (pencil is recommended in case you make errors).
- Be sure to fill out the bubble page **clearly and darkly with no overlaps.**
- Erase any errors completely.
- Provide only the single, most correct answer for each question.

Multiple Choice Questions

ANSWERS FOR THE FOLLOWING MULTIPLE CHOICE MUST BE INPUTTED INTO THE BUBBLE PAGE IN THE ANSWER BOOKLET. ANSWERS RECORDED IN THIS BOOKLET WILL NOT BE MARKED.

1. In this course you were required to create a Team Charter because:
    a. You have never been in an engineering design team before and needed to know what to do for the project.
    b. It tested your knowledge of different teamwork concepts.
    c. It was important to first define how you were going to work to ensure that your team was able to be successful.
    d. It made sure that you got to know who was on your team.

2. The three components of a complete reflection are:
    a. Development, Ideation, Evaluation
    b. Description, Analysis, Evaluation
    c. Description, Ideation, Engagement
    d. Development, Analysis, Engagement

3. Which of the following is **TRUE**?
    a. A constraint limit describes a firm boundary that cannot be violated.
    b. An objective goal describes a firm boundary that cannot be exceeded.
    c. An objective may have both a goal and a limit.
    d. All constraints must have a quantitative limit.

4. What is the most complete description of the goals of multimodality in engineering communication?
    a. Using images to show the service environment and solutions.
    b. To use many different modes of communication in a report
    c. To determine where written words are most apt.
    d. Using the best mode to convey intended information and meaning.

5. How could the concept of triangulation be utilized in the Sidney Smith project?
    a. Defining the optimal point on the building façade to place artwork.
    b. Providing as much research support for a claim as possible.
    c. Providing different types of evidence to support one claim.
    d. Providing three sources of related data to support one claim.

6. In the Black Box Method:
    a. Inputs and outputs are gathered to identify component flows.
    b. Inputs are connected to outputs to identify functions.
    c. Inputs are used to identify outputs and constraints.
    d. Inputs and outputs are gathered to find aspects of the service environment.

7. What best describes the intended audience for an executive summary?
    a. The reader who needs an introduction to the project before reading the full report.
    b. The reader who may only read the executive summary.
    c. The reader who needs a detailed understanding of a specific section of the project.
    d. The reader who will report on a project to the executive of a firm.

8. Why is parallel structure important in an alternative designs section of a design report?
    a. It makes it easier for the reader to compare your designs.
    b. It ensures that each design is equally viable as a solution.
    c. It ensures that each design is addressing each function.
    d. It ensures that formatting guidelines are followed correctly.

9. Which of the following is **TRUE**?
    a. Patents prevent other people from manufacturing a technology indefinitely.
    b. A Canadian patent protects an invention in all jurisdictions.
    c. Patents protect software code.
    d. Patents can only be used to cover new and novel technology.

10. Which alternative design is inside the Design Space?
    a. One that satisfies the scope but does not satisfy all constraints.
    b. One that satisfies all constraints but does not satisfy all functions.
    c. One that satisfies all functions but does not satisfy all objective goals.
    d. One that satisfies all objective goals but does not satisfy the scope.

11. The datum in the Pugh method is:
    a. A minimal viable solution that serves as a baseline for any new idea.
    b. The numerical score for each alternative design
    c. A benchmark for evaluating alternative design ideas.
    d. The set of objectives used to assess each alternative design.

12. In your PR Debrief you received TA feedback that some of your objectives were unmeasurable. Your team decided it had to go back, conduct more research, and add metrics. This is an example of:
    a. Decomposition
    b. Delegation of tasks
    c. Scope creep
    d. Iteration

13. Which is **TRUE** regarding a How-Why tree?
    a. It is used to prioritize objectives.
    b. Ask "Why? Why? Why?" to get to the root cause.
    c. It is used to generate constraints.
    d. Move lower on the tree by asking the question: "How?"

14. You are in the Idea Generation phase and your team is brainstorming together. One of your team members begins eliminating ideas. Your professor jumps out of a bush and says:
    a. "Why is this one team member doing all the eliminating, you should all be doing it!"
    b. "Brainstorming should only be used during the Problem Definition phase!"
    c. "Please do not filter your ideas while brainstorming."
    d. "The client didn't say brainstorm, so don't brainstorm."

15. Once a consolidated list of design ideas is created, which step comes next in the idea selection process?
    a. Multi-voting to reduce the long list of ideas to a manageable number.
    b. Identifying the ideas that best meet the objectives and objective goals.
    c. Using a graphical decision matrix to select the best ideas.
    d. Eliminating ideas that do not meet function and constraint requirements.

16. The purpose of generating detailed requirements in a design process is:
    a. To ensure that the design problem has a solution.
    b. To document and define the design problem.
    c. To expand the design space and solution space.
    d. To show that the design team is following the design process.

17. An ESP design team working on the Sid Smith project this term goes to visit Nathan Phillips Square in front of Toronto City Hall. They observe the way the outdoor area is designed and used to gather information for their project. This activity is called:
    a. Scoping
    b. Benchmarking
    c. Iterating
    d. Designing by analogy

Questions 18 to 18 pertain to Case Study #1: Team Case Study found in the Case Study Booklet – Booklet #3.

---

18. Which revision to the Team Charter should address this situation in the future?
    a. We will make decisions as a team by vote, where majority rules
    b. Team members will respond to messages on Teams within 2 hours.
    c. Lesley will decide on work re-allocation when all team members are not present to decide.
    d. Work will be ready for review by the entire team 1 day in advance of the deadline.

19. Alex wants to provide Kim some feedback on her actions within the team. Which of the following meets the AID model discussed in class?

    a. Your actions were unfair as it made me do more work than everyone else. You should take on unfinished work when you are the only one who is done their work early.

    b. When you assigned Lesley's section to me, I was disappointed as I still had work to do for my sections of the assignment. Because you assigned me that work, I was not able to complete both my and Lesley's work to the standard we discussed in our team charter. In the future, it would be great if you could take on some extra work if you have already completed yours.

    c. Don't think you know more than others about how much work they can handle. Take on some work yourself before telling other people they need to do more.

    d. I found that your decision to make me do extra work was not fair as it did not follow the team charter. Remember that the team charter says we all need to decide on work re-allocation and you aren't the only person who makes this decision.

20. Which of the following Team Charter Ways of Working was likely the cause of this situation?

    a. Complete all work by the deadline.

    b. Everyone decides on work re-allocation if someone does not complete their work on time.

    c. We will meet on Thursdays from 1-2pm when needed.

    d. We will create an environment where everyone feels comfortable to speak their mind.

End of questions pertaining to Case Study #1: Team Case Study.

Questions 21 to 34 pertain to Case Study #2: Better Chip Bag found in the Case Study Booklet – Booklet #3.

---

21. Which of the following sentences from the case study expresses an objective?

    a. Chip bags are often made of plastic, foil and paper laminated together.

    b. In addition to serving as packaging for the chips, the bag also advertises the contents.

    c. The package must not lose its integrity at low or high temperatures.

    d. Ideally the package could be used as a serving dish for the chips with toppings [2].

22. Which of the following sentences from the case study expresses a constraint?
    a. Chip bags are often made of plastic, foil and paper laminated together.
    b. In addition to serving as packaging for the chips, the bag also advertises the contents.
    c. The package must not lose its integrity at low or high temperatures.
    d. Ideally the package could be used as a serving dish for the chips with toppings [2].

23. Which of the following is outside the Scope of this project?
    a. A design that increases marketability of the product.
    b. A design that works for making Dorilocos, a Mexican street food dish.
    c. A design for the material that will be used to make the packaging.
    d. A design for the seal that will keep the packaging airtight.

24. A Structural Decomposition of this problem might include:
    a. Maintain crispness, inexpensive, and biodegradable.
    b. Less noisy, biodegradable, and meets safety standards.
    c. The way the proposed solution can be opened, the way the chips are removed, and the means for keeping the chips crisp.
    d. The packaging material, the seal design, and outer surface of the package.

25. The Functional Basis for this problem includes:
    a. Extracting mass and maintaining information
    b. Transmitting information and storing mass
    c. Maintaining mass and allowing access
    d. Preventing breakage and storing information

26. Stakeholders for this design problem include:
    a. Kellogg's, and government agencies related to municipal recycling programs
    b. Land fill operators, and Kellogg's
    c. Street food vendors (i.e., Evelia Alcala), and government agencies related to municipal recycling programs
    d. Land fill operators, and street food vendors (i.e., Evelia Alcala)

27. A description of the Service Environment for this problem could include:
    a. The design should not break open in grocery bags filled with other groceries.
    b. The outside atmosphere ranges from very low (< 10%) to high (100%) relative humidity.
    c. The design should meet the ISO 17088:2021 standard for biodegradable products.
    d. The seats in aircraft are typically equipped with a drop-down tray for food service.

28. A Secondary Function of the chip packaging is:
    a. Maintaining the crispness of the chips.
    b. Holding as much product as possible.
    c. Displaying product information.
    d. Meeting safety requirements.

29. The design team creating the chip bag wants to turn one of their metrics into a measure of success. Which of their metrics is most relevant to the success of alternative chip bag designs?
    a. Relative Humidity (%) of the environment
    b. Decibels (dB) produced by the packaging when the chips are accessed
    c. Taste and likeability of chips, as measured in [6] [reference in the case study]
    d. Thermal Resistance (R) of the sack material

30. An objective goal for the new chip bag design could be:
    a. Higher taste and likeability ratings
    b. Must not cost more than $0.10 to produce
    c. Prevents moisture from entering the bag
    d. 70 decibels which is below the noise level of competitor chip bags

31. The following is an example of a Universal Design principle used in the chip bag:
    a. Use a reusable hard sided cylinder instead of a bag.
    b. The bag can be opened with low physical-effort.
    c. The bright colours of the chip bag can represent the brand of the chips.
    d. The chip bag is a vessel for transporting compressed air.

32. The following is an example of "Substitute", according to SCAMPER:
    a. Use a reusable hard sided cylinder instead of a bag.
    b. The bag can be opened with low physical-effort.
    c. The bright colours of the chip bag can represent the brand of the chips.
    d. The chip bag is a vessel for transporting compressed air.

33. The case study refers to "... ISO 17088:2021 (if the solution is a plastic) or the equivalent". ISO17088:2021 is:
    a. A code, which is being used as an objective
    b. A standard, which is being used as an objective
    c. A code, which is being used as a constraint
    d. A standard, which is being used as a constraint

34. There are no regulations, such as Accessibility for Ontarians with Disabilities Act, identified in the client statement. This means:
    a. The design team will need to identify relevant regulations for every location where the new design will be used.
    b. Only Canadian regulations will apply to the new design because Big Smoke Chips is based in Toronto.
    c. Because the design must work in many locations, there are no specific regulations that apply to this design problem.
    d. Because this is a design for a chip bag, there are no regulations that will be applicable.

End of questions pertaining to Case Study #2: Better Chip Bag.

End of Multiple-Choice Questions.

There are no more questions in this booklet.

APS111 & APS113 Engineering Strategies and Practice

Instructors: S. McCahan, T. Nolan, B. Kinsella, C. Variawa, and P. Sheridan

Final Examination

ANSWER BOOKLET – Booklet 2

December 9, 2022

6:30 pm – 9:00 pm (2.5 hours)

First name (please write as legibly as possible within the boxes)

Last name

UTORid

Instructions Page

(There are no questions on this page)

- This is a 2.5 hour final exam with 44 questions (34 Multiple Choice and 10 Long Answer). The multiple choice questions are worth 50% of the exam grade and the long answer are worth 50% of the exam grade.
- This is a Type A closed book examination; no aids permitted other than a paper translation-only dictionary (i.e. direct word-to-word translations; no definitions.)
- If you need scrap paper for draft work, ask an invigilator.
- Ensure that you have **THREE** items:
    1. **MULTIPLE CHOICE BOOKLET – Booklet 1**: Contains all the multiple choice questions. **DO NOT** record answers in Booklet 1. Instead fill in the answers to the multiple choice questions on the bubble page found in the ANSWER BOOKLET – Booklet 2. Booklet 1 is **NOT** handed in and the answers will **NOT** be graded.
    2. **ANSWER BOOKLET – Booklet 2**: has all the long answer questions, space to directly answer the long answer questions, and a bubble page to record the answers to the multiple choice questions. The answers to the long answer questions should be recorded directly into **Booklet 2**. Answers to the multiple choice questions should be recorded into the bubble page in **Booklet 2**. Booklet 2 **MUST BE** handed in at the end of the exam.
    3. **CASE STUDY BOOKLET – Booklet 3:** has three case studies. Case Study #1 and #2 are to be used to answer some of the multiple choice questions. Case study #3 is used to answer the long answer questions. **Booklet 3** is **NOT** handed in at the end of the exam.
- **THIS BOOKLET IS ANSWER BOOKLET – Booklet 2.**

Long Answer (50%):

- This component has 10 questions worth a total of 23 marks. These long answer questions are worth 50% of the exam.
- Input your answers to the long answer questions directly into the boxes under the questions in this Exam Booklet. Answers written outside that box will not be marked.
- Use full sentences for the most part, and where appropriate, but if using bullet points, lists or tables, full sentences are not required. In the end, you are assessed on the clarity of the content and meaning in your answers, and not on grammar rules or formality.

Questions 1 to 10 pertain to Case Study #3: Wintertime Wheelchair Wheel Cleaner found in the Case Studies Booklet – Booklet #3.

Long Answer Questions: Wintertime Wheelchair Wheel Cleaner

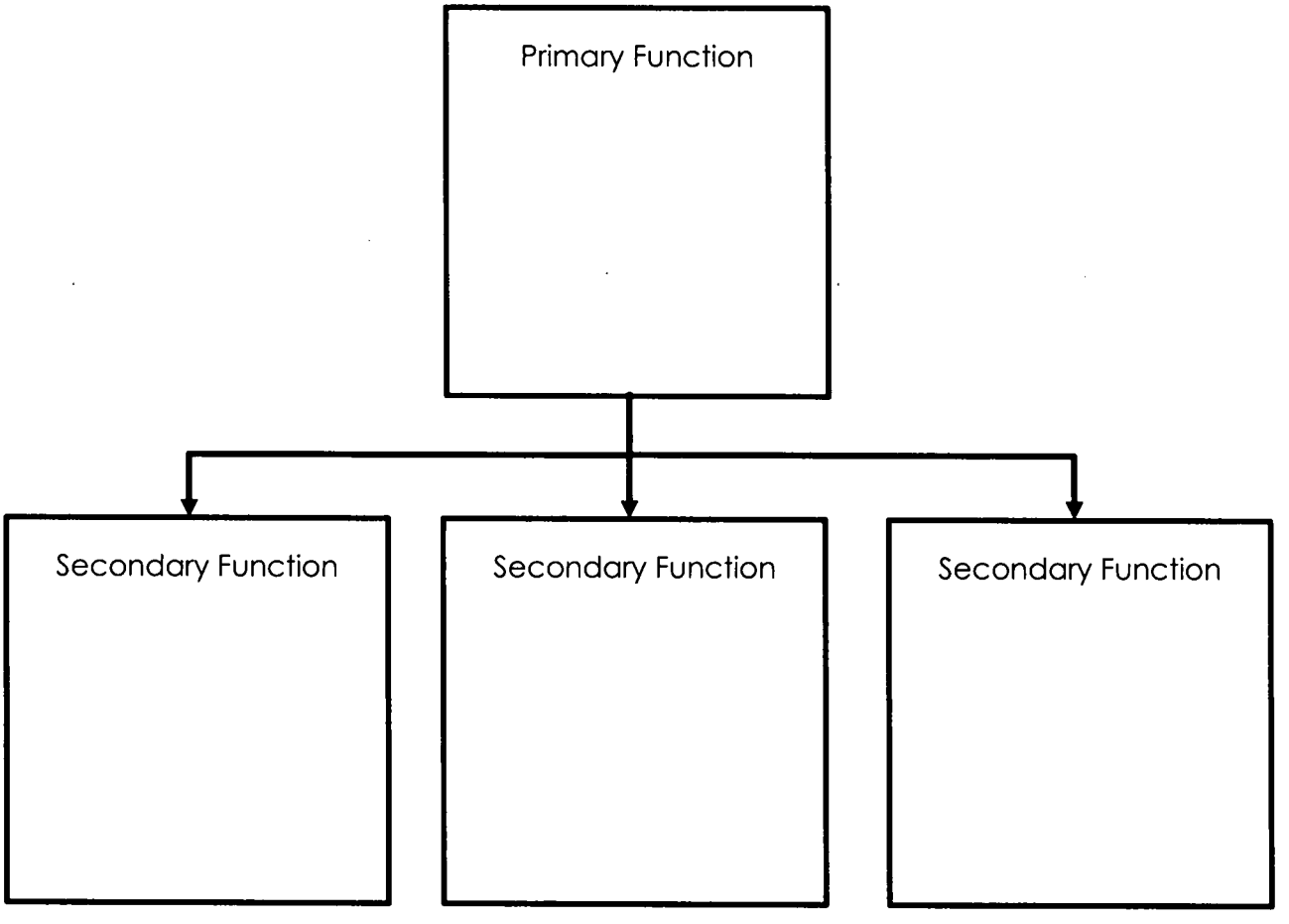
1. [1 mark; <10 words] Identify **ONE** underlying client Need. Do **NOT** include more than one Need. If you identify more than one, only the first will be marked.

2. [1 mark; <10 words] Identify **ONE** Gap related to the Need in Question 1. Do **NOT** include more than one Gap. If you identify more than one, only the first will be marked.

3. [1 mark; 2-3 words] Write **ONE** Functional Basis that addresses the Gap in Question 2. You must use one component and one verb associated with Functional Basis. Do **NOT** add additional qualifiers. If you write more than one Functional Basis, only the first will be marked.

4. [1 mark; 10 words] Write **ONE** Primary Function developed from the Functional Basis in Question 3. If you write more than one Primary Function, only the first one will be marked.

5. [3 marks; 50 words] Complete the following Functional Decomposition. Below, write the Primary Function from Question 4. You must include **THREE** Secondary Functions. If you include more than three Secondary Functions, only the first three will be marked.



6. [2 marks; 15 words] Identify **ONE** important Stakeholder and indicate the potential impact of the design on them. Do not use the client, user, or design team. If you identify more than one Stakeholder, only the first will be marked.

7. [1 mark; 10 words] Write **ONE** Constraint complete with metric. A limit is not required. If you write more than one Constraint, only the first will be marked.

8. [3 marks; <60 words] Write **THREE** measurable Objectives with a metric for each. Goals are not required. If you write more than three Objectives, only the first three will be marked.

Objective #1
Objective #2
Objective #3

9. [4 marks; 50 words] Complete the Morphological Chart below. Write the Secondary Functions from Question 5 as headers for the columns (top row). Add means and use lines to indicate three alternative design solutions.

10. [6 marks; 150 words] Describe **THREE** feasible Design Alternatives generated in Question 9 in the space allocated below. For each design, provide a written description and a visual (rough sketch, diagram, etc.). Use parallel structure to organize your presentation of the designs. If you include more than three designs, only the first three will be marked.

Design #1:

-=Exam Continues on the Next Page=-

Design #2:

Design #3:

End of all questions for this exam.

Name: _____ **Student ID Number:** _____

Instructions:

Please completely fill in the rectangle associated with your response. Example: ■ ☐B ☐C ☐D ☐E

	A	B	C	D	E
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐
11	☐	☐	☐	☐	☐
12	☐	☐	☐	☐	☐
13	☐	☐	☐	☐	☐
14	☐	☐	☐	☐	☐
15	☐	☐	☐	☐	☐
16	☐	☐	☐	☐	☐
17	☐	☐	☐	☐	☐
18	☐	☐	☐	☐	☐
19	☐	☐	☐	☐	☐
20	☐	☐	☐	☐	☐
21	☐	☐	☐	☐	☐
22	☐	☐	☐	☐	☐
23	☐	☐	☐	☐	☐
24	☐	☐	☐	☐	☐
25	☐	☐	☐	☐	☐

	A	B	C	D	E
26	☐	☐	☐	☐	☐
27	☐	☐	☐	☐	☐
28	☐	☐	☐	☐	☐
29	☐	☐	☐	☐	☐
30	☐	☐	☐	☐	☐
31	☐	☐	☐	☐	☐
32	☐	☐	☐	☐	☐
33	☐	☐	☐	☐	☐
34	☐	☐	☐	☐	☐
35	☐	☐	☐	☐	☐
36	☐	☐	☐	☐	☐
37	☐	☐	☐	☐	☐
38	☐	☐	☐	☐	☐
39	☐	☐	☐	☐	☐
40	☐	☐	☐	☐	☐
41	☐	☐	☐	☐	☐
42	☐	☐	☐	☐	☐
43	☐	☐	☐	☐	☐
44	☐	☐	☐	☐	☐
45	☐	☐	☐	☐	☐
46	☐	☐	☐	☐	☐
47	☐	☐	☐	☐	☐
48	☐	☐	☐	☐	☐
49	☐	☐	☐	☐	☐
50	☐	☐	☐	☐	☐

	A	B	C	D	E
51	☐	☐	☐	☐	☐
52	☐	☐	☐	☐	☐
53	☐	☐	☐	☐	☐
54	☐	☐	☐	☐	☐
55	☐	☐	☐	☐	☐
56	☐	☐	☐	☐	☐
57	☐	☐	☐	☐	☐
58	☐	☐	☐	☐	☐
59	☐	☐	☐	☐	☐
60	☐	☐	☐	☐	☐
61	☐	☐	☐	☐	☐
62	☐	☐	☐	☐	☐
63	☐	☐	☐	☐	☐
64	☐	☐	☐	☐	☐
65	☐	☐	☐	☐	☐
66	☐	☐	☐	☐	☐
67	☐	☐	☐	☐	☐
68	☐	☐	☐	☐	☐
69	☐	☐	☐	☐	☐
70	☐	☐	☐	☐	☐
71	☐	☐	☐	☐	☐
72	☐	☐	☐	☐	☐
73	☐	☐	☐	☐	☐
74	☐	☐	☐	☐	☐
75	☐	☐	☐	☐	☐

	A	B	C	D	E
76	☐	☐	☐	☐	☐
77	☐	☐	☐	☐	☐
78	☐	☐	☐	☐	☐
79	☐	☐	☐	☐	☐
80	☐	☐	☐	☐	☐
81	☐	☐	☐	☐	☐
82	☐	☐	☐	☐	☐
83	☐	☐	☐	☐	☐
84	☐	☐	☐	☐	☐
85	☐	☐	☐	☐	☐
86	☐	☐	☐	☐	☐
87	☐	☐	☐	☐	☐
88	☐	☐	☐	☐	☐
89	☐	☐	☐	☐	☐
90	☐	☐	☐	☐	☐
91	☐	☐	☐	☐	☐
92	☐	☐	☐	☐	☐
93	☐	☐	☐	☐	☐
94	☐	☐	☐	☐	☐
95	☐	☐	☐	☐	☐
96	☐	☐	☐	☐	☐
97	☐	☐	☐	☐	☐
98	☐	☐	☐	☐	☐
99	☐	☐	☐	☐	☐
100	☐	☐	☐	☐	☐

APS111 & APS113 Engineering Strategies and Practice

Instructors: Susan McCahan, Ted Nolan, Ben Kinsella, Chirag Variawa and Patricia Sheridan

Final Examination

CASE STUDY BOOKLET – Booklet 3

December 9, 2022

6:30 pm – 9:00 pm (2.5 hours)

Instructions

Below are **THREE** case studies.

1. Case Study #1: Team Case Study
2. Case Study #2: Better Chip Bag Case Study
3. Case Study #3: Wintertime Wheelchair Wheel Cleaner

Case Study #1: Team Case Study is to be used **ONLY** when answering Multiple Choice questions specifically linked to this case study. **DO NOT** use Case Study #1 to answer Long Answer questions.

Case Study #2: Better Chip Bag is to be used **ONLY** when answering Multiple Choice questions specifically linked to this case study. **DO NOT** use Case Study #2 to answer the Long Answer questions.

Case Study #3: Wintertime Wheelchair Wheel Cleaner is to be used **ONLY** when answering the Long Answer questions. **DO NOT** use Case Study #3 to answer the Multiple Choice questions.

There are no questions in this booklet. Since this booklet will not be collected at the end of the exam, you may write on or separate the pages in this booklet. Nothing you write in this booklet will be graded.

Case Study #1– Team Case Study

*Case study #1 is to be used for **ONLY** for the Teams Multiple Choice questions. **DO NOT** use this case study for the Long Answer questions.*

The night before the PR was due, three members of a five-member team (Sam, Alex, and Taylor) were working on their team's document. Sam was concerned that they would not finish on time as Lesley had not completed his section, and the team could not get a hold of him. Kim showed up online at 10PM to ask the team how they were doing, as she was done her part two days in advance. After hearing that Lesley had not completed his part, Kim – the team's project manager – reassigned Lesley's work to Alex. Alex was not happy about this and felt that the situation was unfair as he had not yet completed his part.

Case Study #2 – Multiple Choice: Better Chip Bag

*Case study #2 is to be used for **ONLY** for the Multiple Choice questions. **DO NOT** use this case study for the Long Answer questions.*

Around the world people eat chips, also called crisps, that are sold in plastic bags (see figure 1). There are numerous types of chips and flavors. Some of the most popular are potato chips, corn chips, and snacks (e.g., Popchips). They also come in a range of flavors from the iconic Canadian favorite, ketchup flavored, to popular spicy or cheese flavors. Often the chips are salty and may have a flavoring powder applied to the surface. According to Research and Markets [1], the global potato chip industry alone is expected to reach $39 Billion (US) by 2027, with the market made up of both major global players like Kellogg's and Kraft Foods, as well smaller regional producers.

The ubiquitous bags not only keep the chips crisp and fresh they also keep the powdered coating and aroma contained. The bags are also sometimes used as food serving dishes by street food vendors [2].

Chip bags (technically called sacks) are often made of plastic, foil and paper laminated together. This means that many of the sacks cannot be recycled and do not biodegrade [3]. Some municipalities are now accepting thermoplastic flexible film sacks for recycling, but most end up as garbage [4]. The plastic in these bags is typically biaxially oriented polypropylene (BOPP), which is moisture-resistant to keep the chips at a desirable crispiness even in very humid conditions [5]. In addition to serving as packaging for the chips, the bag also advertises the contents. In a very competitive market, with hundreds of different choices, the bag differentiates the brand [6].

There have been attempts to create biodegradable chip sacks, most notably the introduction of a new sack for SunChips by their parent company PepsiCo®. This sack, however, has been largely criticized for being nosier than traditional packaging [7]. *The Wallstreet Journal* reports that PepsiCo® acknowledged the problem: "Realizing there is no escaping the noise, Frito-Lay featured it in some of its marketing. In stores, the company attached signs to shelves that read: 'Yes, the bag is loud, that's what change sounds like.'" Unfortunately, such messaging cannot totally mitigate the negative consequences of the bag's noise problem. [8]

The client for this project, Big Smoke Chip Company in Toronto Ontario, has considered all the issues discussed above and is now looking for a new design for a chip bag. The new solution:

- Should maintain the crispiness of the chips, in conditions up to 100% relative humidity (i.e., even if the outside of the bag gets wet).
- Must be biodegradable: meets ISO 17088:2021 (if the solution is a plastic) or the equivalent.
- Should be as or less noisy relative to current chip bags.
- Dry air is added to the package during the filling process to ensure the chips do not get crushed during transport. However, this can cause the sack to puff up considerably in low pressure environments such as on airplanes. This can make the package difficult to open. A new solution should be as easy to open as current sack and should not burst in typical low pressure environments (e.g., on aircraft, or in La Paz, Bolivia).

- The package must not lose its integrity at low or high temperatures. It should not become brittle or weak between –50 C and +50 C.
- The package material must seal effectively, handle shipping and transport in bags filled with other groceries without crushing the chips or breaking open.
- Must meet ISO 7965-2:1993 for drop testing for sacks made from thermoplastic flexible film. A new solution made of a different material should also pass this testing to be competitive with current packaging.
- Ideally the package could be used as a serving dish for the chips with toppings [2].
- Should be able to be printed with a wide range of vivid, eye-catching graphics and, at a minimum, must be able to present required information (e.g., ingredients list) readably.

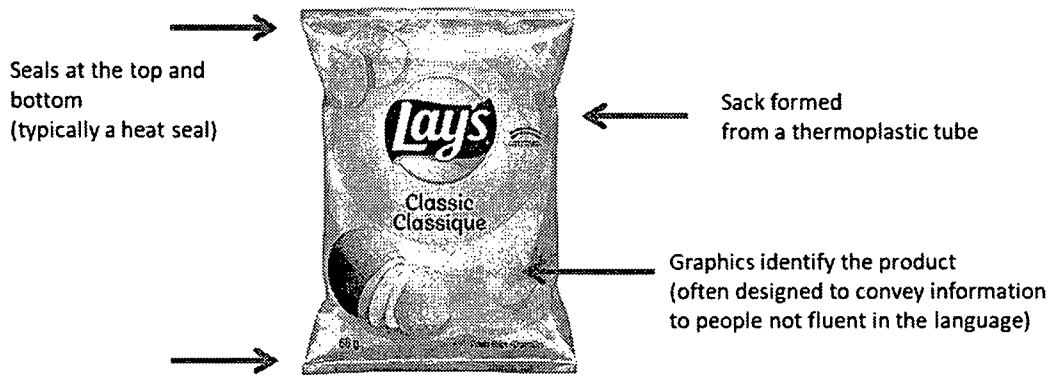


Figure 1. Image of a typical thermoplastic flexible film sack used for potato chips. (reproduced from [9])

References

[1] Research and Markets. "Potato Chips Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2022-2027." Accessed: November 26, 2022. [Online]. Available: https://www.researchandmarkets.com/reports/5682125/potato-chips-market-global-industry-trends#:~:text=The%20global%20potato%20chips%20market,3.24%25%20during%202021%2D2027.

[2]. Nick Miroff, Washington Post. "Crazed snacking on Mexico's streets." featuring Evelia Alcala. Accessed: December 1, 2022. [Online Video]. Available: https://www.youtube.com/watch?v=AccHMLyk_cw&t=15s.

[3] J. R. Catlin, J. M. Leonhardt, Y. Wang, and R. J. Manuel, "Landfill or Recycle? Pro-Environmental Receptacle Labeling Increases Recycling Contamination," *Journal of Consumer Psychology*, vol. 31, no. 4, pp. 765–772, Oct. 2021, doi: 10.1002/jcpy.1216.

[4] City of Calgary. "What Goes Where: Potato Chip Bags." Accessed: November 29, 2022. [Online]. Available: https://www.calgary.ca/waste/what-goes-where/potato-chip-bags.html#:~:text=Chip%20bags%20are%20made%20of,bags%20belong%20in%20the%20garbage

[5] J. Freedman and D. Jurafsky, "Authenticity in America: Class Distinctions in Potato Chip Advertising," *Gastronomica*, vol. 11, no. 4, pp. 46–54, Nov. 2011, doi: 10.1525/gfc.2012.11.4.46.

[6] Y. Jeong, et al., "Prediction of consumer acceptability of potato chips with various moisture contents using survival analysis," *Food Sci Biotechnol*, vol. 22, no. 6, pp. 1621–1627, Dec. 2013, doi: 10.1007/s10068-013-0259-6.

[7] Heathaplexvision. *Potato Chip Technology That Destroys Your Hearing*. (February 23, 2010). Accessed: November 28, 2022. [Online Video]. Available: https://www.youtube.com/watch?v=GyKqj3H02D8&ab_channel=heathaplexvision

[8] S. Vranica. "Snack Attack: Chip Eaters Make Noise About a Crunchy Bag." *Wall Street Journal*. August 18, 2010. [Online] Accessed: November 30, 2022. Available: https://www.wsj.com/articles/SB10001424052748703960004575427150103293906

[9] Zehr's. "Lay's Classic Potato Chips." [online]. Accessed: November 29, 2022. [Online]. Available: https://www.zehrs.ca/potato-chips-classic/p/20797306001_EA

Case Study #3 - Long Answer: Wintertime wheelchair wheel cleaner

*Case study #3 is to be used for **ONLY** for the Long Answer questions. **DO NOT** use this case study for the Multiple Choice questions.*

Mingmei Li is an Industrial Engineer and health care efficiency consultant working with multiple hospitals in downtown Toronto. On any given workday she is moving from one hospital to another, usually on University Avenue where several major hospitals are located in Toronto. Often in the winter months this involves her travelling through "street slush" (See Figure 1) and the road salt used extensively on Toronto streets (See Figure 2). Mingmei then tracks this salty street slush into the various hospitals necessitating the already hard-working hospital staff to clean it up or risk injuries such as slipping on the melting slush. Most hospital entrances have entrance matting designed to allow pedestrians to wipe snow, slush and salt off their footwear (See Figure 3). However, because Mingmei uses a wheelchair, she is unable to use this matting.

Figure 1: "Street slush" is common in Toronto in the winter. [1]

Mingmei, in partnership with the Ontario Disability Coalition, would like a design solution that enables a wheelchair user to clean the snow, slush and salt off their wheels by themselves when entering a building.

Design considerations:

- Hospitals are often busy with people in urgent need. Therefore, the design should be fast to use. Ideally, the time it takes to use the design must be comparable to the time it takes non-wheelchair users to clear slush and salt off boots using a standard entrance mat (See Figure 3). If that is not possible, then this time difference should be minimized.

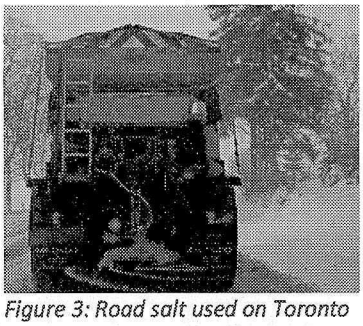


Figure 3: Road salt used on Toronto streets in the winter months. [2]

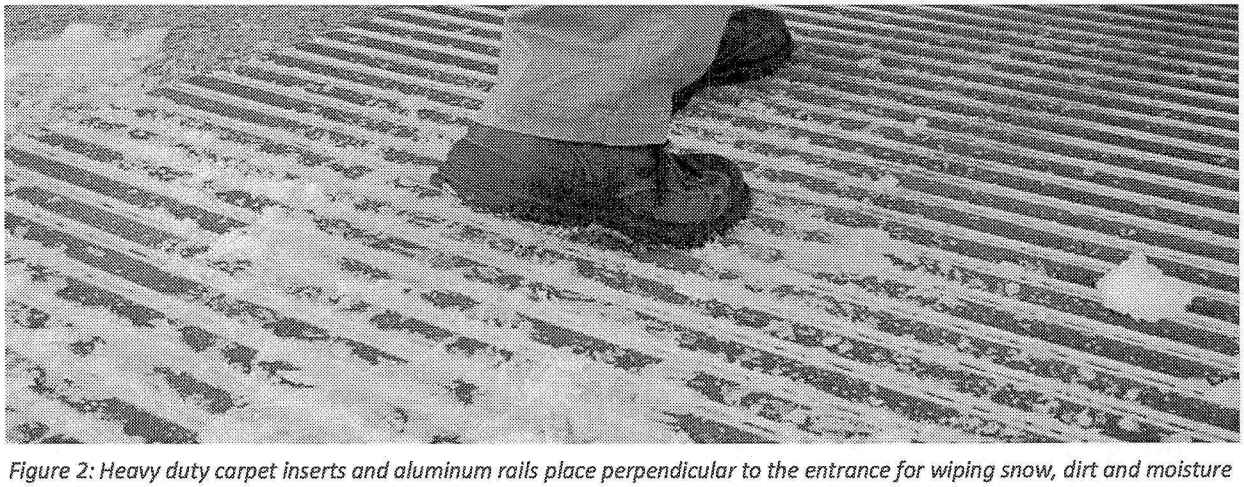


Figure 2: Heavy duty carpet inserts and aluminum rails place perpendicular to the entrance for wiping snow, dirt and moisture off pedestrian's footwear. The recess well underneath the metal mat collects dirt and moisture. [3]

- Mingmei and many other wheelchair users are fiercely independent. She is not interested in a design which requires someone else's help to use.
- The design should use a brush mechanism because it is simple to use and will be durable.
- Designs that require individual upgrades to wheelchairs are acceptable, but are less desirable than designs that place no requirements for modifications on the user's wheelchair.
- Likewise, designs that do not require wheelchair users to carry around tools will be easier to get people to adopt.
- This design is meant to minimize additional work created for hospital caretaking staff by individuals tracking in slush and salt.
- A typical manual wheelchair weighs 35 lbs to 60 lbs. Motorized wheelchairs can weight up to 250 lbs depending on the power of the motor [4]. The design should accommodate all typical wheelchairs. The weight of users is more difficult to define. A nominal user weight range is 100 lbs to over 225 lbs [5].
- Hidden moisture can be a breeding ground for bacteria which is a major concern in a hospital setting. Therefore, if the design must either temporarily store or move the salty meltwater outside. If temporary storage is needed the design must minimize the work needed to empty the storage container.
- Tipping and falling to the ground is a concern for wheelchair users. Often users tip when they reach far enough out of the chair to move the centre of gravity beyond the wheels. Designs should minimize this tipping hazard.
- Salt is very corrosive to metals. Therefore, mental components are not allowed in the design.

References

[1] Tookapic. "Street slush" PIxabay. Dec 01, 2022. [Online] Available: https://pixabay.com/photos/street-city-snow-winter-wet-cold-933241/

[2] Jerzy Górecki. "Road Salt" Pixabay. Dec 01, 2022. [Online] Available: https://pixabay.com/photos/weather-ice-blizzard-plow-way-3920570/

[3] Ronick Matting Systems. "Snow/Rain Entrance Matting." Ronick Matting Systems. Dec 01, 2022. [Online] Available: http://www.ronick.com/snowrain-entrance-matting

[4] 1800 Wheelchair. "How much does a wheelchair weight?" 1800Wheelchair.com. Dec 01, 2022. [Online] Available: https://www.1800wheelchair.com/faq/how-much-does-a-wheelchair-weigh/

[5] Statistics Canada. "Overweight and obese adults." Health Fact Sheets. Dec 01, 2022. [Onlilne]. Available: https://www150.statcan.gc.ca/n1/pub/82-625-x/2019001/article/00005-eng.htm