Engineering Strategies & Practice

Proposed Conceptual Design Specification for Hart House Accessibility Improvements

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November 4, 2024

Executive Summary

The Hart House Theatre is a 104-year-old venue for performances all year long. However, our client and the warden of the Hart House Theatre, David Kim, has recognized inadequate accessibility in the Theatre. The problem, in particular, focuses on the excessively steep ramp in the seating area and the non-wheelchair-friendly access to the stage and backstage.

Upon analyzing the client statement, Mr. Kim has a need for a design that enhances the overall accessibility of the Theatre. The gap in the current space is its lack of accessibility, especially for wheelchair users. Our scope will be the entire interior of the Theatre, with an emphasis on the seating area and backstage.

The primary function of this design is to facilitate the performers in entertaining the audience. Its secondary functions include accessible transportation of performers from the side entrance to backstage and from backstage to stage, seating that supports the audience with all mobility ranges, and accessible entry and exit to the Theatre. The team put together a list of objectives based on the interests of our client, users and stakeholders, and categorized them into safety, usability, strength and being non-disruptive. The constraints of the project were primarily developed by going through relevant articles on the accessibility guidelines, building codes and fire codes, as well as analyzing the client statement.

The team then inspected the service environment of the project, with a specific focus on the layout of the Theatre and human activities. This was followed by research on our stakeholders, which includes the audience, particularly wheelchair users, the performers, our client, and the management staff of the Theatre.

Entering the idea generation stage, the team generated 99 ideas using tools such as free brainstorming, magic solutions and SCAMPER. The list was condensed with a feasibility check and multi-voting, and a morph chart helped combine ideas of audience seating and stage solutions into full system solutions. With further use of multi-voting, weighted decision chart and graphic decision chart, 3 alternative design solutions stood out and were elaborated on. Finally, the team applied the Pugh method to determine the final proposed solution.

To evaluate our proposed solution against the objectives, the team will place heavy loads on the design and determine if it reaches the desired strength. For the objective of safety, the team will simulate the use case of design through Ansys and Solidworks, and determine if it meets our metrics of safety.

The next steps of the project include preparing and conducting tests mentioned in the measure of success, refining and finalizing our CDS upon feedback from the client, and moving forward to the stage of final presentation.

1.0 Introduction

The Hart House Theatre located at 7 Hart House Circle in the University of Toronto faces accessibility challenges, as identified by the client, David Kim. A thirteen-degree incline in the seating area and a lack of wheelchair access to the backstage hinder inclusivity and do not abide by standard regulations. The conceptual design report addresses these issues, aiming to create an accessible space for the audience and crew members. This report outlines the problem and describes the requirements for the design, stakeholder considerations, the design process, and measures of success for an inclusive theatre.

2.0 Problem Statement

The Hart House Theatre at the University of Toronto, is a year-round venue for a variety of productions (see Figure 1). However, David Kim has identified a lack of accessibility in the theatre. Notably, the ramp at the rear of the seating area has a thirteen-degree incline (see Appendix B), which surpasses code regulations [8]. Furthermore, crew members with mobility issues, mainly those in wheelchairs, cannot access the backstage without using the stairs [4].

Therefore, there is a need for a solution that improves accessibility within the Hart House Theatre, focusing on the seating area and the backstage. This need is driven by the client's aspiration to cultivate an inclusive environment for the audience and crew members.

The scope of this project will be the majority of the interior of the Hart House Theatre, including the seating area, stage, hallways, and backstage [3]. The scope ranges vertically from the ceiling to the floor. This extensive scope helps maximize the generation of solutions to improve accessibility.

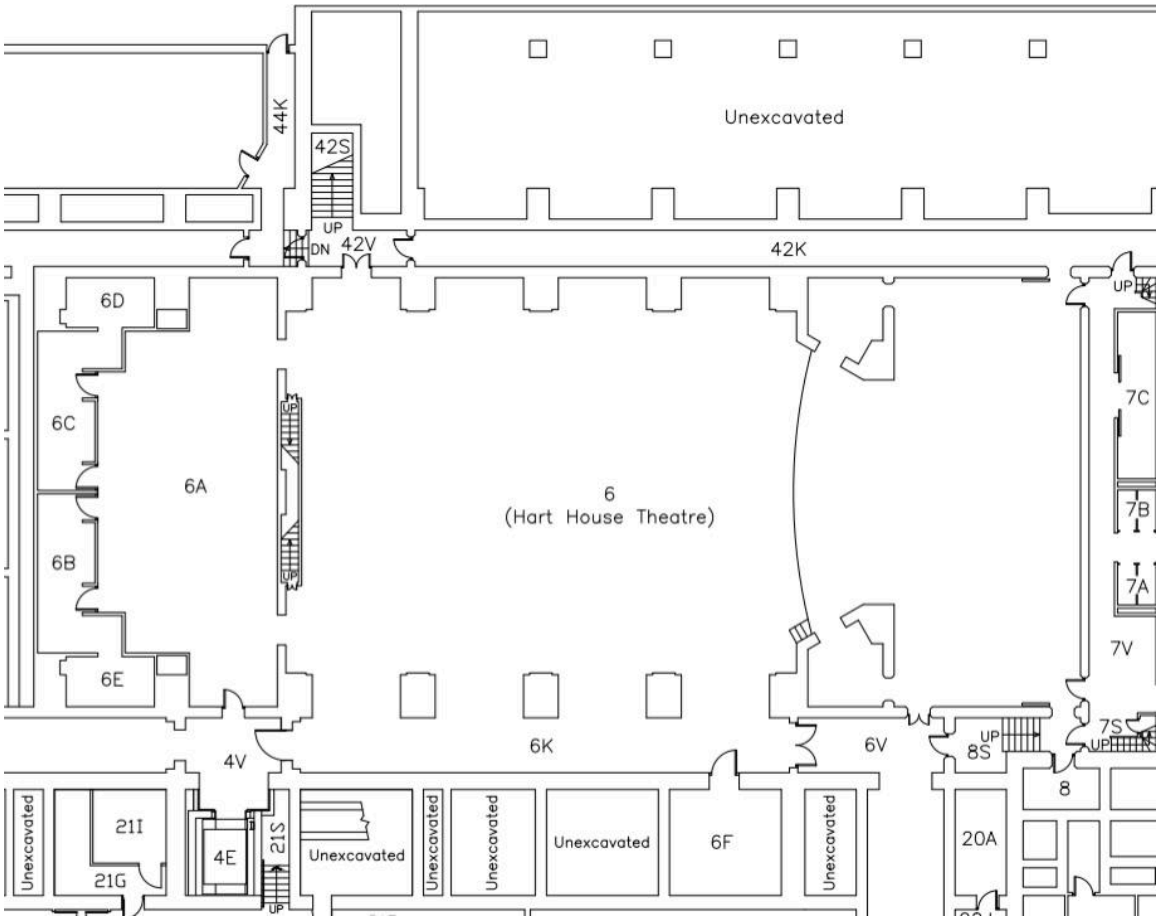

Figure 1. Location of the Theatre within Hart House (sub-basement level)

3.0 Detailed Requirements

To address the issue of accessibility at Hart House Theatre, the design must safely transport those with disabilities and must be inclusive. A successful design will be one that can transport the mass of an individual in a safe manner that does not obstruct other aspects of the theatre.

3.1 Functions

Functions are responsible for what the design will do and the actions it will perform. In this case, the design will support and transport the mass of the actors and members of the audience. The method used to determine the function is in Appendix A. The primary and secondary functions of the design are specified below.

Primary function:

- Transform actors into a live performance for the audience

Secondary functions:

- Transport actors from the side entrance to backstage

- Transport actors of all mobility ranges onto the stage from backstage
- Transport actors of all mobility ranges off the stage and into the backstage
- Seating supports audience members of all mobility ranges
- Audience members of all mobility ranges can enter and exit the theatre through the main doors

3.2 Objectives

This section outlines objectives of the accessible wheelchair seating and wheelchair stage accessway that will need to be accomplished to be considered successful (see Appendix J for the pairwise comparison chart for ranking objectives).

Objective	Goal	Metric
Safety	• Should meet the Ontario building code section s.3.4.6.1 and s.3.8.3.4 • Should meet the Ontario Human Rights code chapter 19	• Exceeds all sections of code outlined in 'Goals' (more details in Appendix B)
Usability	• Should provide good efficiency and usability for mobility challenged individuals	• Hold a minimum of 363 kg [2] • Take less than 2 minutes to get from the main entrance to the seating area, and from the entrance of the seating area to the backstage • Surface should yield a coefficient of friction greater than or equal to 0.5 [3]
Strength	• Should be made of materials that can withstand years of wear and tear from high compressive forces	• Require no maintenance • Material has 2500-4000 PSI resistance [22]

Non-disruptive design	• Should not disrupt Hart House's aesthetic or operational features	• Produce less than 35 dB of the sound [15] • Colour scheme should match the rest of the theatre • Allows all other functions of the facility to continue when in use

Table 1: Objectives and metrics

3.3 Constraints

Table 2 outlines the constraints of the project pertaining to the accessible seating and wheelchair stage access of the theatre, adhering to the wants of the client and regulations:

Constraint	Explanation
Accessibility Guidelines	The design must follow accessibility guidelines. Relevant sections include: • Ontario Building Code, O Reg. 332/23 s.3.4.6.1 • Canada Transportation Act, section 238 • Ontario Building Code, O Reg. 332/23, s.3.8.3.4 • Toronto Accessibility design guidelines, section 1.1.9
Flow/Aesthetic	The design must not disrupt the audience/performers during shows. • The design must not be the same colour as the rest of the theatre to demonstrate the area that the design occupies [9] • The design must not produce more than 60 dB of noise upon usage [15] • The design must not obstruct the view of the user or other persons [9]
Fire Safety	The design must not conflict with the Ontario Fire Code, or Fire Protection and Prevention Act of Ontario. • Egress points should not be moved further than 15m away from any part of the theatre [16] • Seating must be in place next to the disabled seating to allow someone to aid their exit of the building [16]

Table 2: constraints and explanations

4.0 Service Environments

This section will focus on where the design project will be operating and who will be affected. This includes different elements that might be in the environment, such as living beings or inanimate objects.

- The design will operate inside the Hart House Theatre, which is in downtown Toronto.
- The environment has limited space:
    - Backstage: This space mainly consists of dressing rooms and hallways. This space is also for storage and moving equipment in and out of the stage [5].
    - Stage: This space is open but is used solely for performances.
    - Audience: This space is limited as it is filled with seats (see Figures 2 and 3).
    - The amount of space present is important because this will determine how much space we have available for our design.
- The presence of people and life will vary depending on when there are performances, rehearsals, or no performances:
    - During performances: There will be many people, with the theatre being able to seat a maximum of 428 people [12]. There may also be audience members with service animals.
    - No performances (excluding rehearsals): There will be no or extremely few people.
    - During rehearsals: There will be people but fewer than when there are performances.
    - It is important to note the number of performers who will be backstage. That number may reach a maximum of 75-80 people [4].
    - The number of people present is important because it influences how much space is available for our design and where our design will be located.
- Virtual environment:
    - The theatre has access to the Internet; however, our design will not be affected by any virtual elements such as service networks or the Internet.

Figure 2. Demonstration of the seating arrangement in the theatre. From this picture, we can see that the seats fill the majority of the audience section. There are walkways along the middle and both sides of the seating area.

Figure 3. This image shows the audience seating from a separate angle. We can see that the chairs occupy most of the theatre space.

5.0 Stakeholders

Stakeholders are people or organizations that have a stake or interest in the development of the Hart House. They play a part in every step of the design process

Table 3 lists the stakeholders from highest to lowest priority and their impact on the project:

Stakeholder	Rationale for Inclusion
The audience	They are the primary target group for the design.
Wheelchair users that form part of the audience	The design aims to achieve an inclusive and accessible model for them.
David Kim [11]	Mr. Kim is the client who identifies the problem and is the warden of the Hart House. Changes made to the Hart House affect him directly.
Doug Floyd [12]	Mr. Floyd is the director of the Theatre and Performing Arts at the Hart House Theatre. His input on enhancing the audience experience will be insightful.
Michael Morrin [11]	Mr. Morrin is the Facilities and Capital Projects Supervisor for Hart House. The renewal of Hart House infrastructure will concern him. In this case, there is an addition of accessible

	features to the existing infrastructure.

Table 3. List of Stakeholders and Contributions

See Appendix C for more stakeholders and stakeholder consultations.

6.0 Generation, Selection, and Description of Alternative Designs

During the idea generation phase, methods such as blue sky thinking, magic solutions and SCAMPER produced 99 ideas. A feasibility check reduced this to 65, categorized by relevance to the stage, audience, or both. The team used multi-voting and a morph chart for refinement, then a weighted decision chart to narrow down the top 10 ideas. A graphic decision chart selected the top 3, which were then researched.

6.1 Idea Generation Process

To generate ideas, a variety of tools were used. In Appendix D, the ideas created using each of these tools are listed and explained. Table 4 showcases a summary of the number of ideas created using each process.

	Blue Sky Thinking	Magic Solution	Analogy	SCAMPER	Free Brainstorm	Structured Brainstorm
Stage	5	3	6	26	11	11
Audience	5	4	1	-	6	8
Both	6	-	2	2	5	1
Total	16	7	9	28	22	20

Table 4. Idea Generation Methods

After using the idea generation tools, a full set of solutions was compiled and can be seen in Appendix E. Ideas were sorted by whether they pertained to the problem of stage access, seating access, or both. The list was further divided into sections based on similarities.

6.2 Alternative Design Selection Process

The team then performed a feasibility check, which is explained in Appendix F, and applied multi-voting, which is detailed in Appendix G.

Following this, the team created a morph chart to combine audience seating solutions and stage solutions to form full solutions. The process for morph chart combinations is explained in Appendix H.

The team then used multi-voting to reduce the number of full system solutions to 18, as shown in Appendix I. Next, a weighted decision matrix is utilized to further decrease our ideas. Table 5 shows the weight distribution assigned to each objective, determined by a pair-wise decision chart shown in Appendix J.

Objectives	Rank	Weighted Percentage
Follow codes/safety	1	40%
Usability	2	30%
Strength	3	20%
Non-disruptive	4	10%

Table 5. Weighted decision matrix (explanation in appendix J).

The team evaluates each solution against the objectives and rates it from 0 to 10. Next, the weighted score for all 18 solutions is calculated, and the solutions with the 10 highest scores are retained. The scale for objective evaluation and the table that summarizes the scores are shown in Appendix K.

The top 10 solutions were then placed into a graphic decision chart (figure 4) to determine the three alternative design solutions.

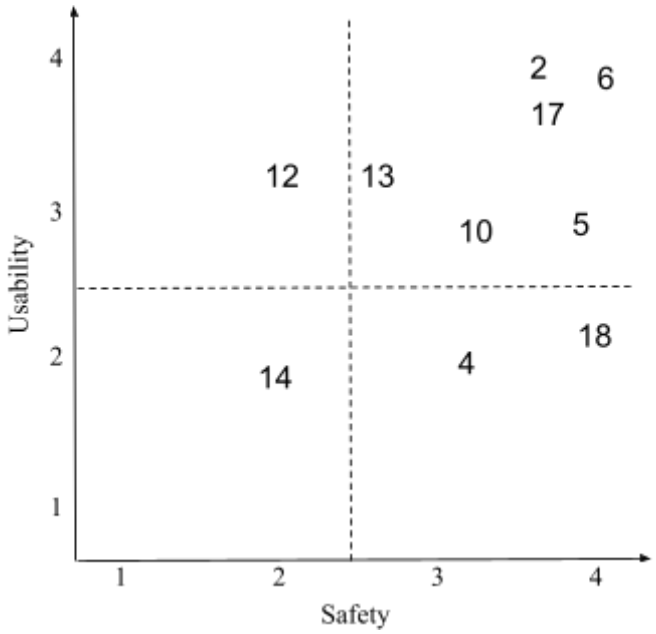

Figure 4. Graphic decision chart

Ideas 2, 6 and 17 are left as our 3 alternative designs (referred to as design options 1, 2, and 3, respectively).

The flowchart below summarizes the idea selection process, showing how the final design was chosen (see Figure 5).

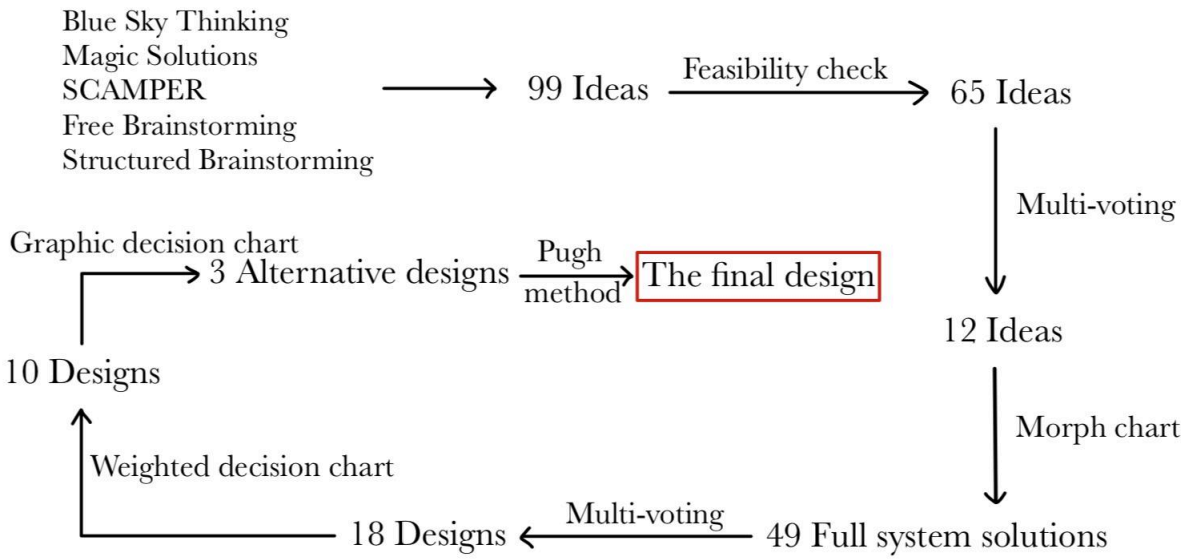

Figure 5. Flowchart of the idea selection process.

6.3 Alternative Design Descriptions

This section outlines and describes our three alternative designs. An analysis of the functions, objectives, and constraints is provided in each design's specific appendix.

6.3.1 Design Option 1 - Row adjustment and stair climbing assistance

See Appendix L for functions, objectives, and constraints (originally idea #2).

Row adjustment:

- The row adjustment solution involves a mechanism to increase the space between rows of seats. The increased space is for wheelchair users and individuals with mobility issues who require more support (see Figure 6). The mechanism to adjust the rows will be operated through a control panel, accessible by staff. Existing seating will be remodelled to follow the code and be ergonomic [10].

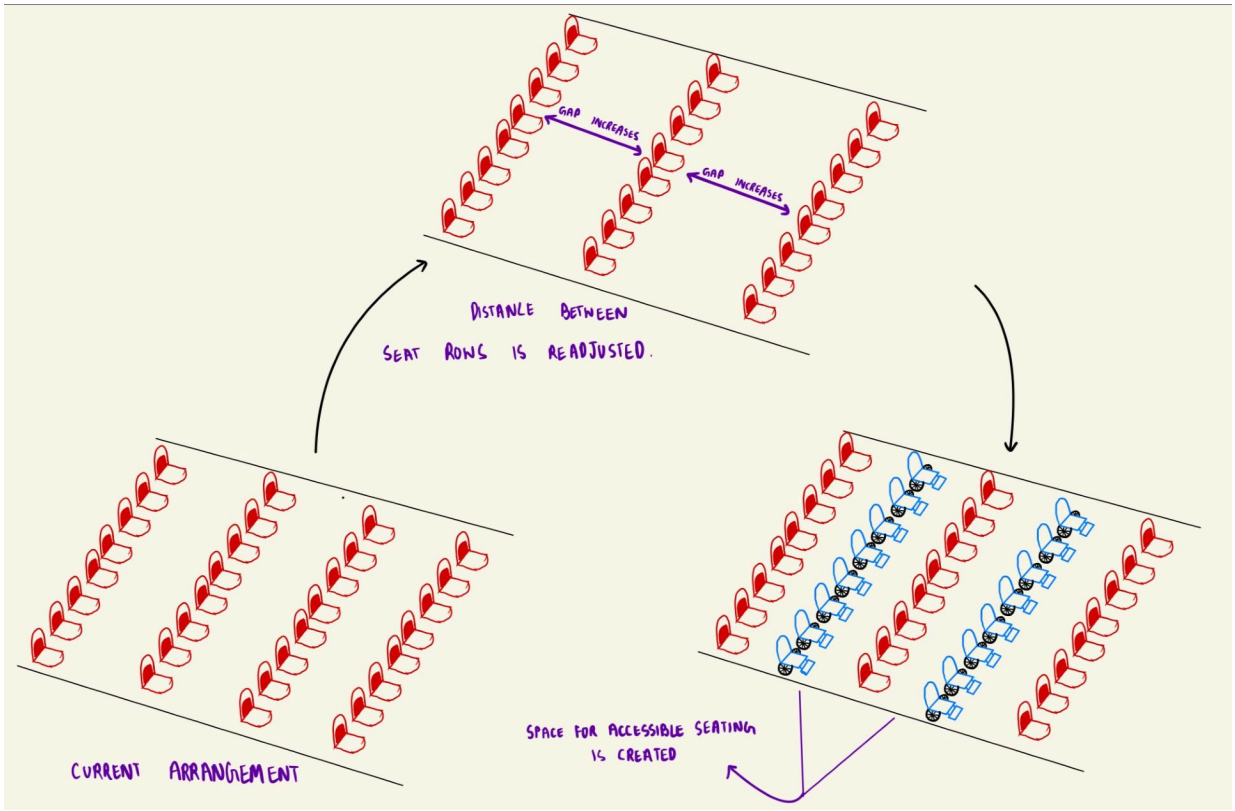

Figure 6. Demonstration of row adjustment design

Stair climbing assistance:

- The stage solution involves installing a motorized inclined platform lift backstage. This will replace the small set of 2 black stairs. The new access will be exclusively for disabled individuals, as there are two other entrances for able-bodied performers [7]. The motorized platform will elevate users from ground level to the stage level, and back. It will have a control panel to control the up and down movement options for the lift.

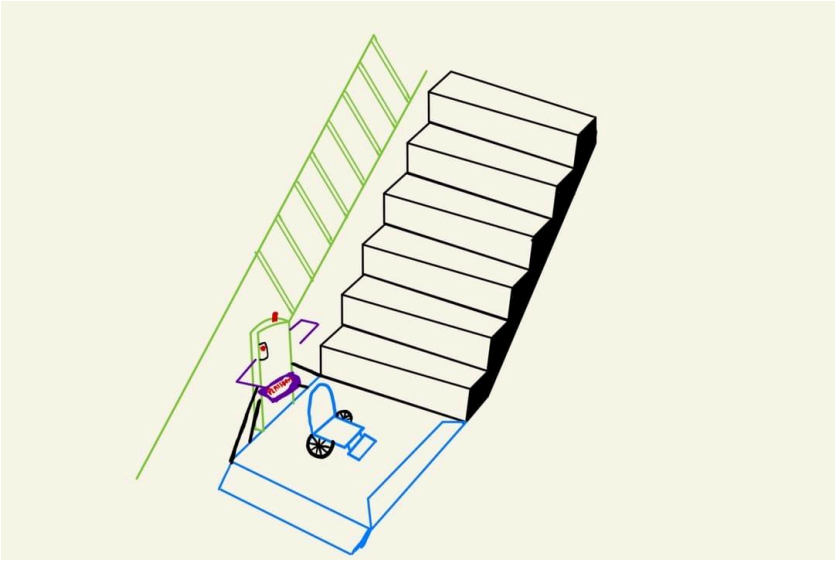
figure 7. Stair climbing assistance device

6.3.2 Design Option 2 - Adjustable platform and wheelchair lift

See Appendix M for functions, objectives, and constraints (Originally idea #6).

Adjustable platform:

- As a seating solution, this design proposes to install an adjustable platform on top of the existing theatre floor. The platform can switch between a horizontal position, which becomes level with the theatre entrance, and a lowered position which has an angle of 3.5° (see Figure 8). The platforms will replace the original normal seating at the back of the theatre (see Figure 9). The main material that will be used to build the platforms is stainless steel.

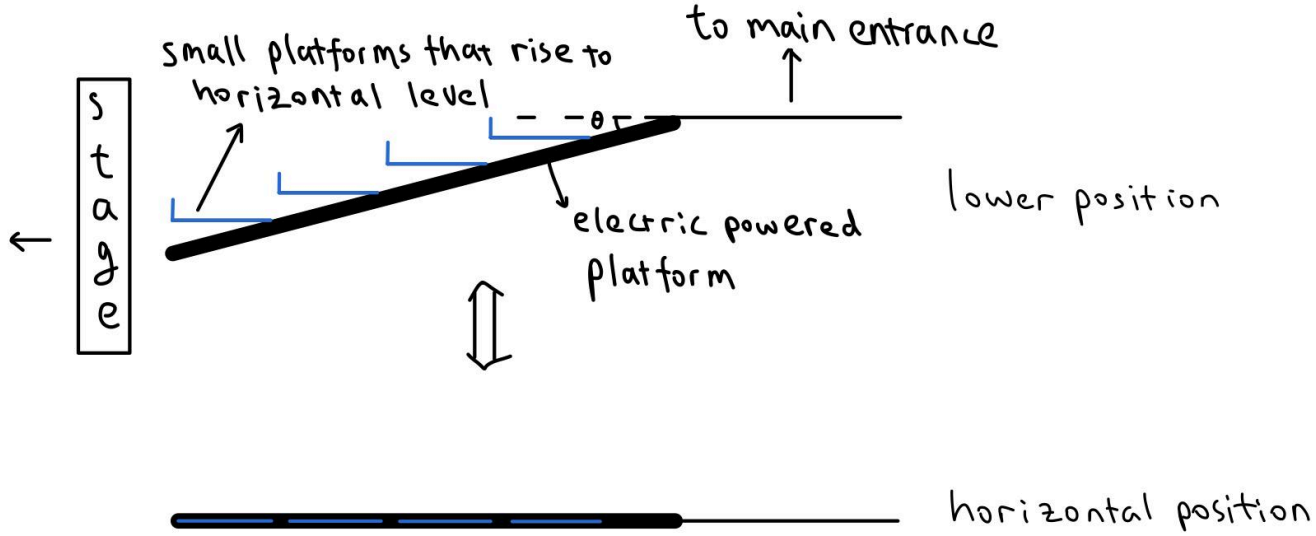

Figure 8. Demonstration of the side view of the "platform" design.

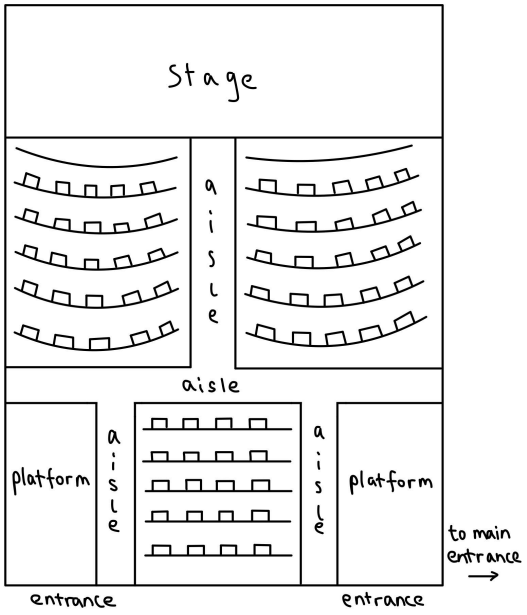

Figure 9. Location of the platforms in the Theatre.

Wheelchair lift:

- For the stage part of the solution, a wheelchair lift will be installed backstage in the first staircase that is directly across the doors that lead from the audience to backstage. The wheelchair lift will be implemented into the staircase. The user will be assisted onto the lift and lifted up the stairs into the backstage (see Figure 10). The main material that will be used to build the lift will be stainless steel.

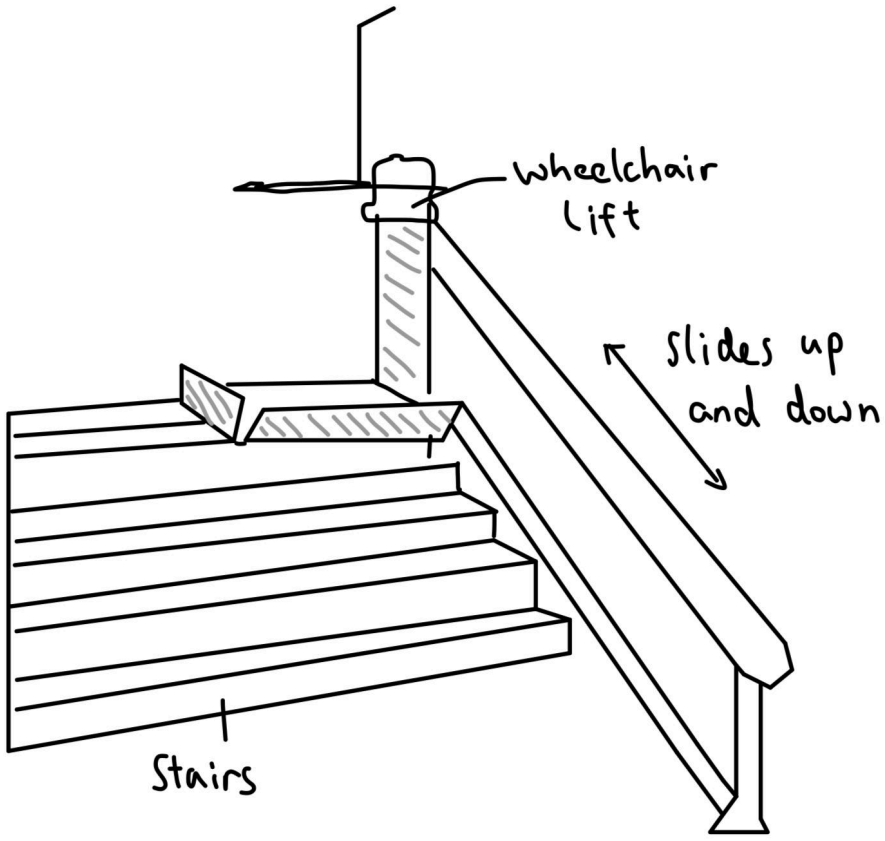

Figure 10. Wheelchair Lifting Mechanism.

6.3.3 Design Option 3 - New seating area and run-off ramp

See appendix N for functions, objectives, and constraints (Originally idea #17)

New seating area:

- This solution suggests accessible seating being added to the back of the theatre. The back wall of the theatre (between the seating area and the canteen) will be torn down, and the accessible seating area will be placed there (see Figure 11). The old disabled seating will be turned into regular theatre seats.

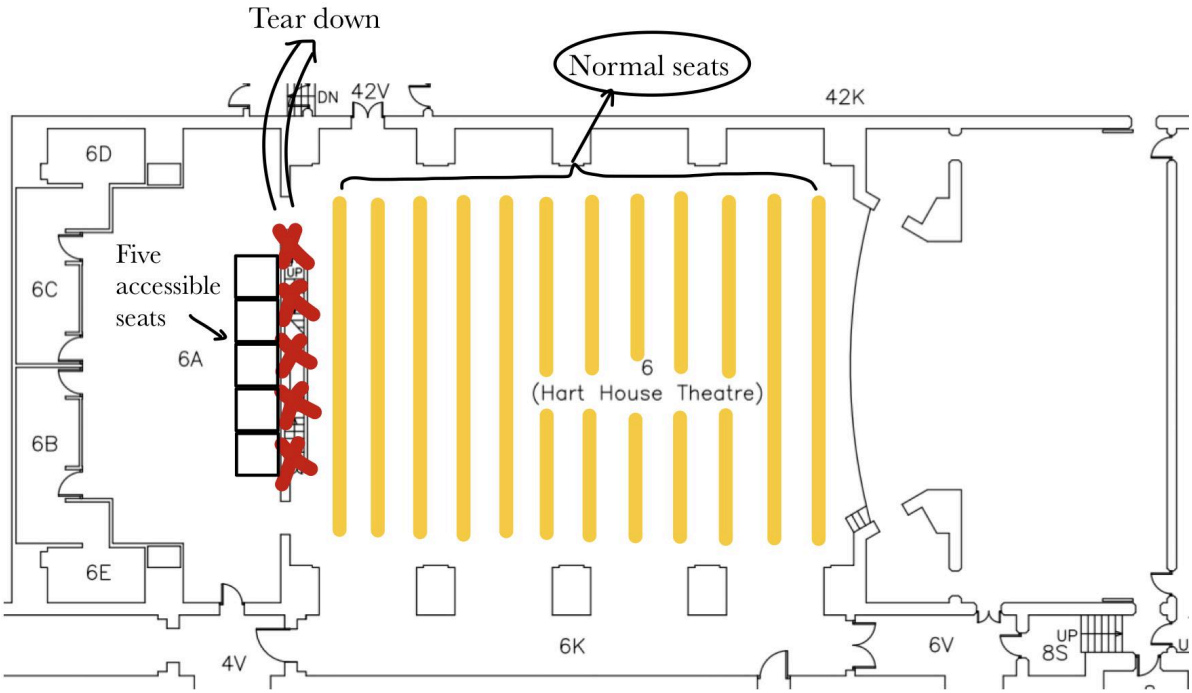

Figure 11. Demonstration of the audience solution for design 17.

Run-off ramp:

- This solution involves building a wall along the length of the ramp at the theatre's entrance. Behind this wall will be a low incline ramp leading to the side of the stage (see Figure 12). The hallway will be for performers' use only and will be behind doors operable by wheelchair-accessible buttons.

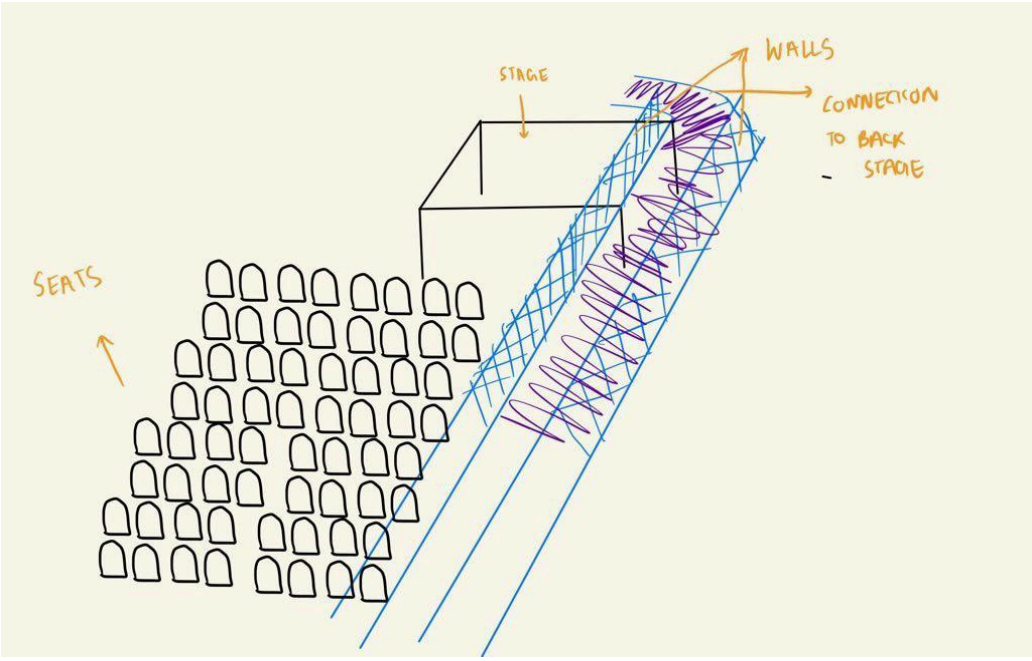

Figure 12. Demonstration of the stage solution for design 3.

7.0 Proposed Conceptual Design Specification

To finalize the proposed design solution, the Pugh chart shown in Table 6 was used.

Pugh Chart	Option 3	Option 1	Option 2
Safety	S	0	-1
Usability	S	-1	0
Strength	S	1	-1
Non-disruptive	S	-1	-1
SUM	0	-1	-3

Table 6. Pugh chart

Design option 3 was chosen as the datum due to sharing similar qualities to options 1 and 2. After comparing the designs against the 4 objectives, option 3 was identified as the best design. More detail about the rankings is detailed in Appendix O.

David Kim requested an inclusive design for the theatre, specifically addressing accessibility concerns for those with mobility challenges. This aligns with the gap, and therefore, the design needs to be inclusive to all individuals visiting Hart House. Option 3 solves this issue by creating a straight passageway from the theatre entrance to the stage, accommodating individuals with diverse mobility ranges. Additionally, the back wall of the theatre will be replaced with an accessible seating zone to enhance overall accessibility. The largest factor in implementing this design is that it is a permanent and convenient solution compared to other designs due to being non-disruptive and usable (see Appendix P).

8.0 Measures of Success

This section will detail tests evaluating the design against project objectives. Table 7 describes tests for the audience seating and stage solution.

Objective	**Metric**	**Test**
Strength	Force per square inch: Compressive forces the concrete is subjected to per square inch without cracking Force per square inch:	Audience: 1. Objects with a weight of 363 kg or greater will be placed on the concrete platform. 2. We will determine if the platform can withstand the force by checking if there

	Tensile forces the steel is subjected to per square inch without bending	are any cracks or fractures after placing the weights on. 3. If there are no fractures, that means the platform can successfully withstand the force. Stage: 1. A simulation will be run where a mass of 363 kg and greater will be placed on a wheelchair. 2. The wheelchair will be rolled up the ramp to the backstage. 3. We will observe if the ramp experiences any cracks or fractures. 4. If there are no cracks or fractures, the ramp can safely support the weight of the wheelchair user.
Follows code/safety	Slope/incline of surfaces and ability to contain persons	Audience: 1. The bar that replaces the torn down wall (to separate wheelchair seating from other seating) will be tested prior to being installed by holding the weight of 5 adult males (force of 4488N across its length of 3.7m and height of 1m). Stage: 1. Using Solidworks/Ansys, create a ramp with an incline of 3°. 2. Apply the constraints (walls, doors) in the simulation. 3. Build a concrete ramp which is reinforced with steel at the base. 4. Apply the expected load of multiple wheelchairs on the ramp 5. Run the simulation and analyze the results to ensure that the design is safe to use.

Table 7: Objective tests

Additional measures of success can be seen in Appendix Q.

9.0 Conclusion

The conceptual design specifications report has explored innovative solutions to address the non-inclusive theatre. Of these, a design was chosen that creates an inclusive and welcoming environment for individuals with mobility limitations. The implementation of this design will improve the quality of the experience at Hart House theatre, for those with and without disabilities.

The next steps of the project include preparing and conducting the tests for the measure of success, revising and finalizing the CDS upon feedback from the client, and moving forward to the stage of the final presentation.

10.0 Reference List

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Appendix A

In the client statement, David Kim stated, “Creating a sense of inclusion and belonging for all members of the community is an important goal for this project” [5]. From this, we can determine that the primary function must enhance the primary purpose of the theatre, which is to bring communities together to enjoy performances. In order for this to occur, the primary function must be to facilitate the performers in entertaining the audience. When the primary function of the design is to make it easier for performers to entertain the audience, it will make the theatre an enjoyable experience for all members of the community.

To determine the secondary functions of our design, we first used the functional basis method to analyze the design problem. This method states that every technology can be categorized as controlling mass, energy, or information.

The client also stated he would like to “improve functionality and accessibility of this venue.” and “allow a broad population of patrons and performers to fully utilize the facility” [5]. Using the functional basis method, we can determine that in order to improve accessibility for a broad population of patrons, the design must transport mass and support mass. This enables the secondary functions of transporting performers and actors of all mobility ranges into and out of the theatre.

Appendix B

Group 140 visited Hart House on Tuesday, October 3rd and Thursday, October 5th. We took measurements of ramp angles, took pictures, and took notes on anything that seemed relevant to the project requirements.
Metrics of objectives:

Safety -

- Should have a minimum width of 900 mm [9]
- Should create less than a 3.5° incline [9]
- Wheelchair-accessible seating design should allow seating for at least 5 average (25×32 inches) wheelchairs[1]
- Should have graspable handrails: between 30 mm and 40 mm in diameter [9], and between 865 mm and 965 mm in height (measured from the ramp's surface) [9]
- Should have a level area of at least 1670 mm by 1670 mm at the top and bottom of a ramp. [17]

Appendix C

There are a number of other staff members of Hart House who have interests in the project but have not been explicitly listed due to the extensive list. For example, Ms. Sara Filipowski, the audience service coordinator in the theatre, could provide valuable insights on improvements to the seating area.

Stakeholder	Rationale for Inclusion
Lena Forest[11]	She is the Warden's Office Project Coordinator for Hart House. Her approval and suggestions will be important.
Sherry Kulman[11]	She is the Senior Director and Chief Administrative Officer of Hart House. Her approval and guidance are pivotal.
Jenifer Newcombe[11]	She is the Director of Strategic Initiatives. Her input on the idea and how it may be improved will be beneficial
Brian Campbell [11]	He is the Technical Director of the Hart House. His opinions would be insightful.
Justin Kim [11]	Mr. Kim is the Financial Officer for Hart House. He is essential in providing a budget for the accessibility features.

Table 1. Stakeholders

The stakeholder consultations noted for Hart House are:

1. Diverse program offerings with particular strengths in innovative arts and global learning dialogue and wellness that reflect student interests and create space for growth and development.
2. Student-led experiences and programming frameworks that support student agency and leadership.
3. Strong partnerships and collaborations that foster connections with and among students, staff, faculty, alumni and community.
4. Infrastructure and a broad range of facilities, including a theatre and art museum.
5. A revenue model that utilizes the resources in creative ways to enhance Hart House as a space for ceremony and celebration.
6. A vibrant Hart House brand that supports awareness and engagement.
7. A demonstrated commitment to inclusivity and tri-campus involvement that can be further developed.
8. Focus on opportunities for wellness, community building and connection.

Appendix D

The team decided to use a variety of idea-generation methods in order to compile a diverse list of solutions. The methods that we used included blue sky solutions, magic solutions, analogies, scamper, free brainstorming, and structured brainstorming. We will list each of these methods, explain the process behind it, and showcase the ideas that were generated by that particular method.

Blue sky thinking is a method that encourages a group to imagine what is possible when unbound by conventional constraints. Blue sky ideas are idealistic and may not take into account monetary, safety, or other constraints.

For example, one of our blue sky thinking ideas is to give all individuals with disabilities prosthetics so they are able to travel easily. This idea took the input of "difficult transporting mass" and returned an output of prosthetic limbs. While this may not be the most feasible solution due to high expenses, in an ideal world this solution would work

The ideas generated by blue sky thinking are as follows:

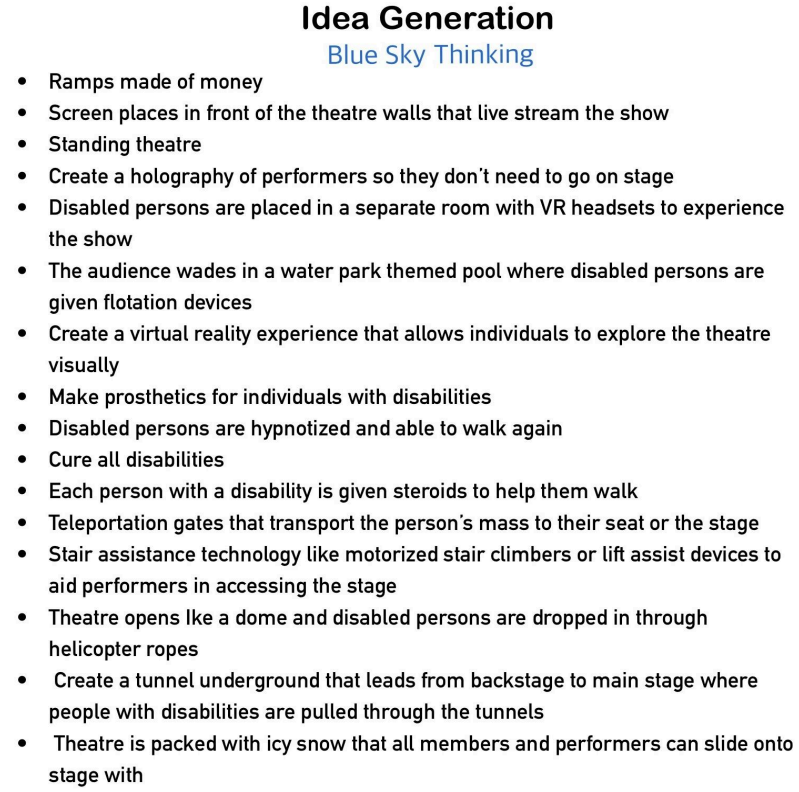


Figure 1. Blue sky thinking ideas

Magic solutions are ideas that solve a component of a solution with "magic". These ideas are useful in expanding the design space and can be reworked into feasible ideas.

For example, A magical solution idea on our list is a "mechanism to propel disabled persons onto the stage using controlled air". While the exact mechanism to concentrate and propel air is unknown, it can be researched and reworked later in the iteration process.
The ideas generated by magic solutions are seen in Figure 2:

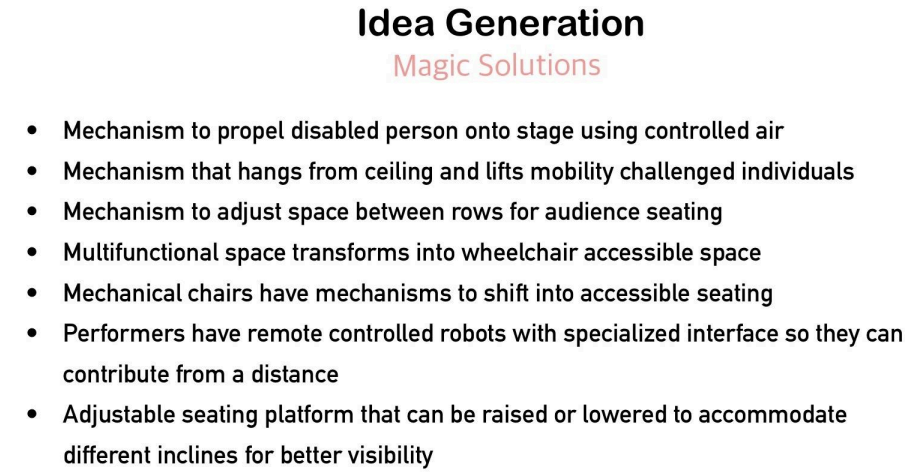


Figure 2. Magic solution ideas

Analogies are a tool that can be used to analyze problems in other projects that are similar and apply them to one's own project. (??). In this design project, the team took inspiration from objects around us that were designed to transport or move mass and applied them to the theatre.

Below are the examples generated from analogies as well as the original inspiration behind the ideas:

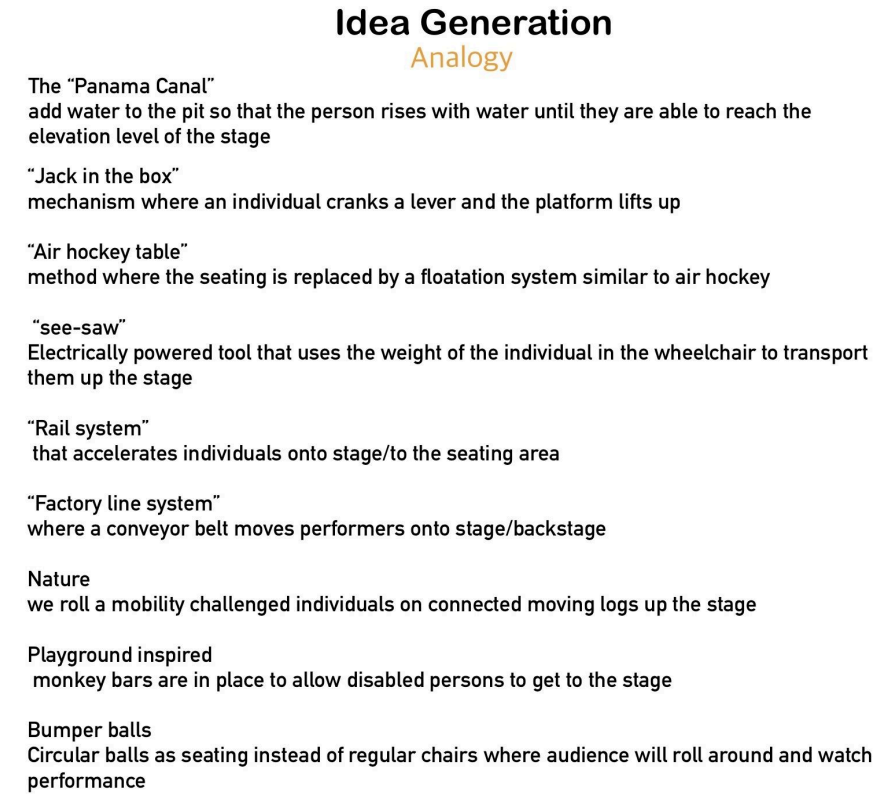


Figure 3. Analogy ideas

Scamper is an acronym that stands for Substitute, combine, adapt, modify, put to other uses, eliminate, and rearrange. In this project, Scamper was helpful in finding substitutes and alternative ideas that accomplish the same task.
For example, in one of our brainstorming sessions, we had the idea of using a wheelchair lift to elevate individuals onto the stage. From this initial idea, a scrambler was used to generate a list of ideas that "elevate" including a hydraulic stage platform that can be adjusted to different heights and helium balloons to be attached to a wheelchair

Figure 4 shows the full list of ideas generated by scamper

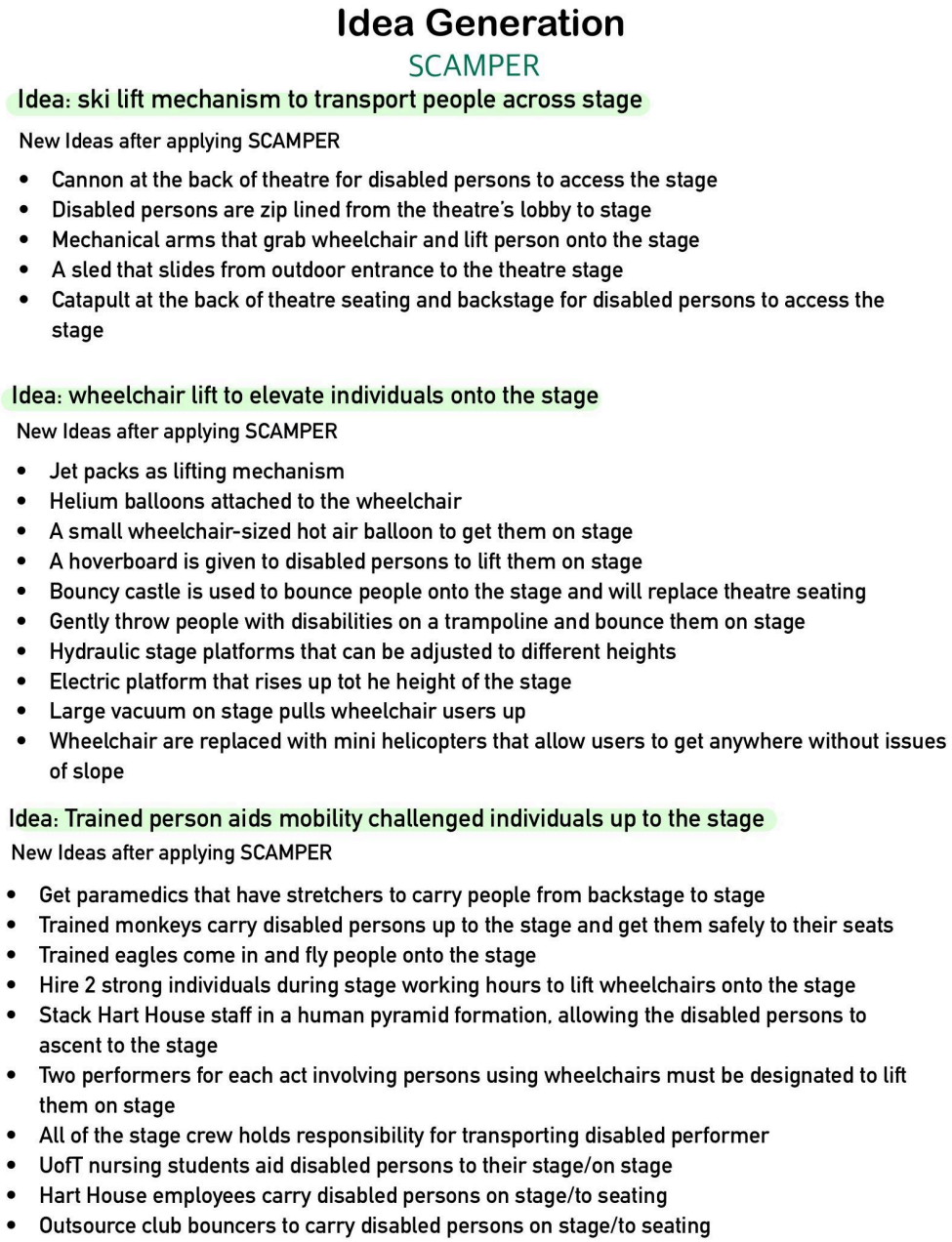


Figure 4. Scamper ideas

Free brainstorming is a method in which members of the team gather together and verbally exchange ideas while one member records the progress. This allows team members to build on one another's ideas and create a large volume of ideas at once. The ideas generated in the free brainstorming session were compiled and are shown below (figure 5):

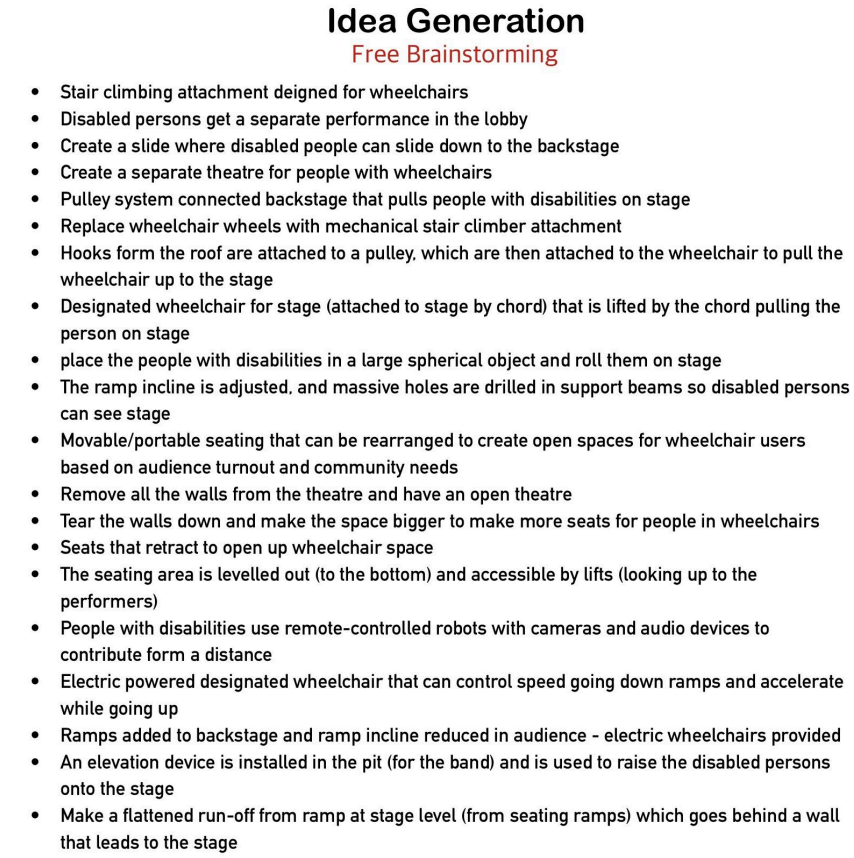


Figure 5. Free brainstorming ideas

Structured brainstorming is a method where a team gathers together and dedicates an allotted time towards individual brainstorming. After this time passes, the ideas are shared and recorded. The ideas compiled in the structured brainstorming session are shown below (figure 6):

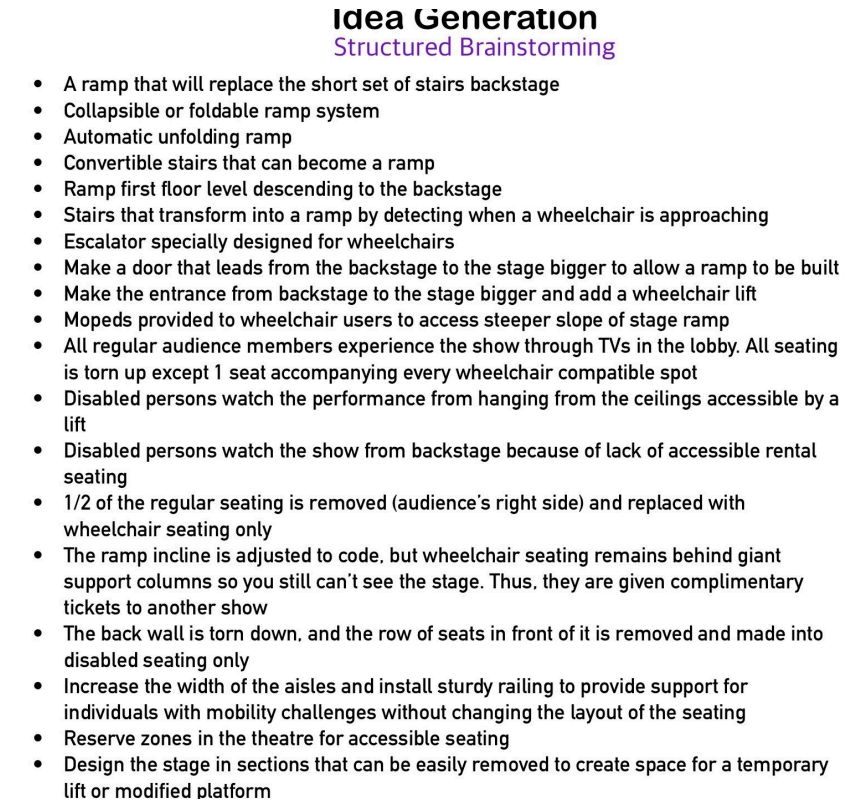


Figure 6. Structured brainstorming

Appendix E

Master list of ideas:

STAGE:

RAMPS:

1. A ramp that will replace the short set of stairs backstage
2. Collapsible or foldable ramp system
3. Automatic unfolding ramp
4. A conveyor belt that moves performers onto the stage/backstage
5. Convertible stairs that can become a ramp
6. The rail system that accelerates the disabled persons onto the stage/to seating
7. Stair climbing attachment designed for wheelchairs
8. Ramp first-floor level descending to the backstage
9. Ramps made of money (cash) from the profit of Chestnut Residence dining hall
10. The theatre is packed with icy snow that all audience members and performers can slide onto the stage with
11. Create a slide where disabled people can slide down to the backstage
12. Make flattened run-off from the ramp at stage level (from seating ramps) which goes behind a wall that leads to stage

13. Stairs that transform into a ramp by detecting when a wheelchair is approaching.
14. electrically powered “see-saw” which uses the weight of the individual in the wheelchair to transport them up the stage, similar to a ramp.

LIFTING MECHANISM:

15. Jet packs
16. Helium balloons attached to the wheelchair
17. A small wheelchair-sized hot air balloon to get them to stage
18. Wheelchair lift to rise to the stage (backstage)
19. A hoverboard is given to disabled persons to lift them on stage
20. Mechanism that hangs from the ceiling and lifts mobility-challenged individuals (magic solution)
21. Catapult at the back of the theatre seating and backstage for disabled persons to access the stage
22. Cannon at the back of the theatre seating and backstage for disabled persons to access stage
23. Disabled persons are ziplined from the theatre's lobby to stage
24. Escalator specially designed for wheelchairs
25. An elevation device is installed in the pit (for the band) and is used to raise the disabled persons onto stage
26. Hooks from the roof are attached to a pulley, which is then attached to the wheelchair to pull the wheelchair up to the stage.
27. Pulley system connected backstage that pulls people with disabilities on stage
28. Mechanical arms that grab the wheelchair and lift the person on stage
29. The Panama Canal - add water to the pit so that the person rises with water until he/she is able to reach the level of the stage (analogy)
30. Electric platform that rises up to the height of the stage
31. Roll a disabled person in a wheelchair on logs up to the stage (analogy)
32. Replace wheelchair wheels with mechanical stair climber attachment
33. A large vacuum on stage pulls wheelchair users up
34. “Jack in the box” mechanism where an individual cranks a lever and the platform lifts up.

STAGE ALTERATION:

35. Design the stage in sections that can be easily removed to create space for a temporary lift or modified platform.
36. Hydraulic Stage Platforms that can be adjusted to different heights
37. Make the door that leads from the backstage to the stage bigger to allow a ramp to be built
38. Make the entrance from backstage to the stage bigger and add a wheelchair lift
39. Create a tunnel underground that leads from the backstage to the stage, where people with disabilities are pulled through tunnel
40. Designated wheelchair for stage (attached to stage by chord) that is lifted by the chord pulling the person on stage

DISTANCED SOLUTIONS:

41. Create a holography of the performers so that they don’t need to go onto stage

42. Performers have remote-controlled robots with audio and visual interfaces so they can contribute from a distance

EXTERNAL AID:

43. Get paramedics that have stretchers that carry people from backstage to stage
44. Throw people with disabilities on a trampoline to bounce them on stage
45. Stair assistance technology like motorized stair climbers or lift assist devices to aid performers in accessing the stage (blue sky thinking)
46. Monkey bars are in place to allow disabled persons to get to stage
47. Trained monkeys carry disabled persons up to the stage and get them safely to their seats
48. Trained eagles come in and fly the people onto the stage.
49. Hire 2 strong individuals during stage working hours to lift wheelchairs onto the stage.
50. The theatre opens like a dome and disabled persons are dropped in through helicopter ropes
51. Place the people with disabilities in a large spherical object and roll them on stage
52. Stack Hart House staff in a human pyramid formation, allowing the disabled persons to ascend to stage
53. Mopeds are provided to wheelchair users to access the steeper slope of stage ramp
54. Two performers from each act involving persons using wheelchairs must be designated to lift them on stage
55. All of the stage crew holds the responsibility of transporting the disabled performer

AUDIENCE:

REGULAR SEATS ALTERATION:

56. The ramp incline is adjusted, and massive holes are drilled in support beams so disabled persons can see stage
57. Movable/portable seating that can be rearranged to create open spaces for wheelchair users based on audience turnout and community needs
58. Disabled seating stays the same but with screens in front of the walls that block the stage that live stream the show
59. All audience members have to get into bumper balls, all seats are removed, and performances are viewed from inside the balls
60. Mechanism to adjust space between rows
61. Remove all the walls from the theatre and have an open theatre
62. Tear the walls down and make the space bigger to make more seats for people in wheelchairs
63. Bouncy Castle replaces the theatre seating with an entrance to the castle by the theatre lobby/bar
64. Adjustable seating platform that can be raised or lowered to accommodate different inclines for better visibility

SEPARATION:

65. Disabled persons get a separate performance in the lobby
66. Standing theatre (no seats, open room for wheelchairs)
67. Disabled persons are placed in a separate room with VR headsets to experience the show

68. All regular audience members experience the show through TVs in the lobby. All seating is torn up except 1 seat accompanying every wheelchair-compatible spot
69. Disabled persons watch the performance from hanging from the ceiling, accessible by lift
70. The sled that slides from the outdoor entrance to Theatre
71. The audience wades in a water park-themed pool (disabled persons are given flotation devices)
72. Disabled persons watch the show from backstage because of the lack of accessible frontal seating
73. ½ of the regular seating is removed (audience's right side) and replaced with wheelchair seating only
74. create a seating area that is multifunctional and serves multiple purposes, such as transforming into wheel-chair accessible spaces when needed (magic solution)
75. The ramp incline is adjusted to code, but wheelchair seating remains behind giant support columns, so you still can't see the stage. Thus, they are given complimentary tickets to a real show (Sunny is such a funny comedy special at Meridian Hall)
76. The back wall is torn down, and the row of seats in front of it is removed and made into disabled seating only
77. Increase the width of the aisles and install sturdy railings to provide support for individuals with mobility challenges without changing the layout of the seating
78. Mechanical chairs that shift from regular seating to platforms for accessible seating
79. Reserve zones in the theatre for accessible seating
80. Seats that retract to open up wheelchair space
81. Seating is replaced by an 'air-hockey table' type floatation system

BOTH (Stage and Audience)

82. Hart House employees carry disabled persons on stage/to seating
83. Outsource club bouncers to carry disabled persons on stage/to seating
84. Make the entrance from backstage to the stage bigger and add a wheelchair lift
85. Create a virtual reality experience that allows individuals to explore the theatre visually
86. Disabled persons are placed on a sloped moving walkway that accelerates them to their seats/on stage
87. The seating area is levelled out (to the bottom) and accessible by lifts (looking up to performers)
88. Make prosthetics for individuals with disabilities (blue sky thinking)
89. Disabled persons are hypnotized and able to walk again
90. Wheelchairs are replaced with mini helicopters that allow users to get anywhere without issues of slope
91. People with disabilities use remote-controlled robots with cameras and audio devices to contribute from a distance
92. Cure all disabilities
93. Create a separate theatre for people with wheelchairs (Inclusive)
94. We give steroids to people with disabilities (magic solution)
95. Teleportation gates that transport the person's mass to their seat and stage
96. Large fans on the floor propel disabled persons on stage
97. UofT nursing students aid disabled persons to their seats/on stage

98. An electric-powered designated wheelchair that can control speed going down ramps and accelerate while going up
99. Ramps added to backstage and ramp incline reduced in audience - electric wheelchairs provided

Appendix F

List after feasibility check:

RAMPS:

1. A ramp that will replace the short set of stairs backstage
2. Collapsible or foldable ramp system
3. Automatic unfolding ramp
4. A conveyor belt that moves performers onto the stage/backstage
5. Convertible stairs that can become a ramp
6. Ramp first-floor level descending to the backstage
7. Ramps made of money (cash) from the profit of Chestnut Residence dining hall
8. Stairs that transform into a ramp by detecting when a wheelchair is approaching
9. Electrically powered "see-saw" which uses the weight of the individual in the wheelchair to transport them up the stage, similar to a ramp

LIFTING MECHANISM:

10. Jet packs
11. A hoverboard is given to disabled persons to lift them on stage
12. Catapult at the back of the theatre seating and backstage for disabled persons to access the stage
13. Escalator specially designed for wheelchairs
14. An elevation device is installed in the pit (for the band) and is used to raise the disabled persons onto stage
15. Hooks from the roof are attached to a pulley, which is then attached to the wheelchair to pull the wheelchair up to stage
16. The pulley system connected backstage pulls people with disabilities on stage
17. Mechanical arms that grab the wheelchair and lift the person on stage
18. The Panama Canal - add water to the pit so that the person rises with water until he/she is able to reach the level of stage
19. Roll a disabled person in a wheelchair on logs up to stage
20. Replace wheelchair wheels with mechanical stair climber attachment
21. Large vacuum on the stage pulls wheelchair users up

STAGE ALTERATION:

22. Design the stage in sections that can be easily removed to create space for a temporary lift or modified platform.
23. Hydraulic Stage Platforms that can be adjusted to different heights
24. Make the door that leads from the backstage to the stage bigger to allow a ramp to be built
25. Make the entrance from backstage to the stage bigger and add a wheelchair lift
26. Create a tunnel underground that leads from the backstage to the stage, where people with disabilities are pulled through the tunnels

27. Designated wheelchair for stage (attached to stage by chord) that is lifted by the chord pulling the person on stage

DISTANCED SOLUTIONS:

28. Create a holography of the performers so that they don't need to go onto stage
29. Performers have remote-controlled robots with audio and visual interfaces so they can contribute from a distance

EXTERNAL AID:

30. Get paramedics that have stretchers that carry people from backstage to stage
31. Monkey bars are in place to allow disabled persons to get to stage
32. The theatre opens like a dome, and disabled persons are dropped in through helicopter ropes
33. Stack Hart House staff in a human pyramid formation, allowing the disabled persons to ascend to stage
34. Two performers from each act involving persons using wheelchairs must be designated to lift them on stage
35. All of the stage crew holds the responsibility of transporting the disabled performer

AUDIENCE:

REGULAR SEATS ALTERATION:

36. Disabled seating stays the same but with screens in front of the walls that block the stage that live stream the show
37. All audience members have to get into bumper balls, all seats are removed, and performances are viewed from inside the balls
38. Mechanism to adjust space between rows
39. Remove all the walls from the theatre and have an open theatre
40. Bouncy Castle replaces the theatre seating with an entrance to the castle by the theatre lobby/bar

SEPARATION:

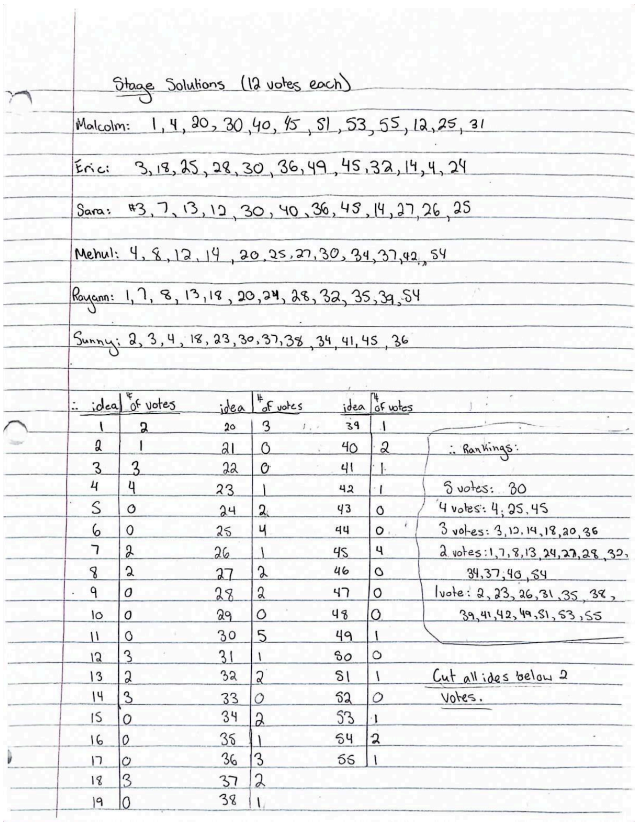
41. Disabled persons get a separate performance in the lobby
42. Disabled persons are placed in a separate room with VR headsets to experience the show
43. All regular audience members experience the show through TVs in the lobby. All seating is torn up except 1 seat accompanying every wheelchair-compatible spot
44. The audience wades in a water park-themed pool (disabled persons are given flotation devices)
45. One-half of the regular seating is removed (audience's right side) and replaced with wheelchair seating only
46. create a seating area that is multifunctional and serves multiple purposes, such as transforming into wheel-chair accessible spaces when needed
47. The back wall is torn down, and the row of seats in front of it is removed and made into disabled seating only
48. Increase the width of the aisles and install sturdy railings to provide support for individuals with mobility challenges without changing the layout of the seating

49. Mechanical chairs that shift from regular seating to platforms for accessible seating
50. Reserve zones in the theatre for accessible seating
51. Seats that retract to open up wheelchair space
52. Seating is replaced by an ‘air-hockey table’ type floatation system

    BOTH (Stage and Audience)
53. Make the entrance from backstage to the stage bigger and add a wheelchair lift
54. Create a virtual reality experience that allows individuals to explore the theatre visually
55. Disabled persons are placed on a sloped moving walkway that accelerates them to their seats/on stage
56. The seating area is levelled out (to the bottom) and accessible by lifts (looking up to performers)
57. Make prosthetics for individuals with disabilities
58. Disabled persons are hypnotized and able to walk again
59. People with disabilities use remote-controlled robots with cameras and audio devices to contribute from a distance
60. Cure all disabilities
61. Create a separate theatre for people with wheelchairs
62. We give steroids to people with disabilities
63. Teleportation gates that transport the person’s mass to their seat and stage
64. UofT nursing students aid disabled persons to their seats/on stage
65. An electric-powered designated wheelchair that can control speed going down ramps and accelerate while going up

Appendix G

The team began the selection process with multivoting:



Stage Solutions (12 votes each)

Malcolm: 1, 4, 20, 30, 40, 45, 51, 53, 55, 12, 25, 31

Eric: 3, 18, 25, 28, 30, 36, 49, 45, 32, 14, 4, 24

Sara: 43, 7, 13, 12, 30, 40, 36, 45, 14, 27, 26, 25

Mehul: 4, 8, 12, 14, 20, 25, 27, 30, 34, 37, 42, 54

Roygann: 1, 7, 8, 13, 18, 20, 24, 28, 32, 35, 39, 54

Sunny: 2, 3, 4, 18, 23, 30, 37, 38, 34, 41, 45, 36

idea	# of votes	idea	# of votes	idea	# of votes
1	2	20	3	39	1
2	1	21	0	40	2
3	3	22	0	41	1
4	4	23	1	42	1
5	0	24	2	43	0
6	0	25	4	44	0
7	2	26	1	45	4
8	2	27	2	46	0
9	0	28	2	47	0
10	0	29	0	48	0
11	0	30	5	49	1
12	3	31	1	50	0
13	2	32	2	51	1
14	3	33	0	52	0
15	0	34	2	53	1
16	0	35	1	54	2
17	0	36	3	55	1
18	3	37	2		
19	0	38	1		

∴ Rankings:

5 votes: 30

4 votes: 4, 25, 45

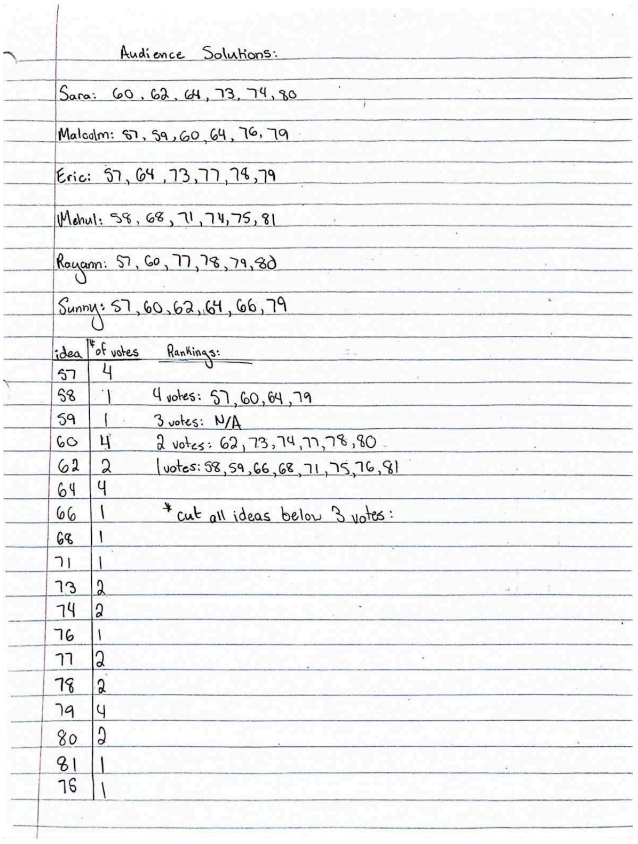
3 votes: 3, 12, 14, 18, 20, 36

2 votes: 1, 7, 8, 13, 24, 27, 28, 32, 34, 37, 40, 54

1 vote: 2, 23, 26, 31, 35, 38, 39, 41, 42, 49, 51, 53, 55

Cut all ides below 2 votes.

Figure 7. Multivoting on the 55 ‘stage’ design ideas



Audience Solutions:

Sara: 60, 62, 64, 73, 74, 80

Malcolm: 57, 59, 60, 64, 76, 79

Eric: 57, 64, 73, 77, 78, 79

Mehul: 58, 68, 71, 74, 75, 81

Roygann: 57, 60, 77, 78, 79, 80

Sunny: 57, 60, 62, 64, 66, 79

idea	# of votes
57	4
58	1
59	1
60	4
62	2
64	4
66	1
68	1
71	1
73	2
74	2
76	1
77	2
78	2
79	4
80	2
81	1
76	1

Rankings:

4 votes: 57, 60, 64, 79

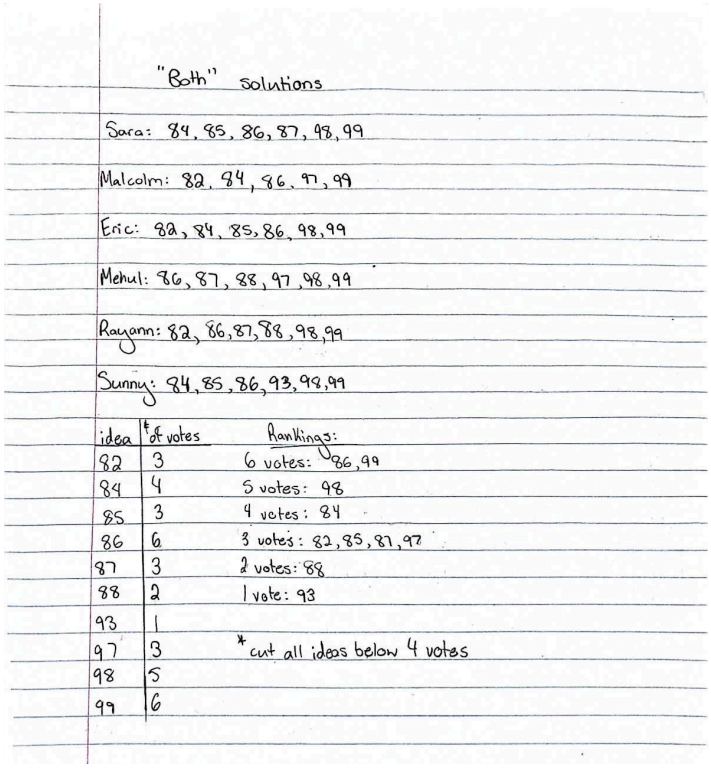
3 votes: N/A

2 votes: 62, 73, 74, 77, 78, 80

1 votes: 58, 59, 66, 68, 71, 75, 76, 81

* cut all ideas below 3 votes:

Figure 8. Multivoting on the 25 ‘Audience’ design ideas



"Both" solutions

Sara: 84, 85, 86, 87, 98, 99

Malcolm: 82, 84, 86, 97, 99

Eric: 82, 84, 85, 86, 98, 99

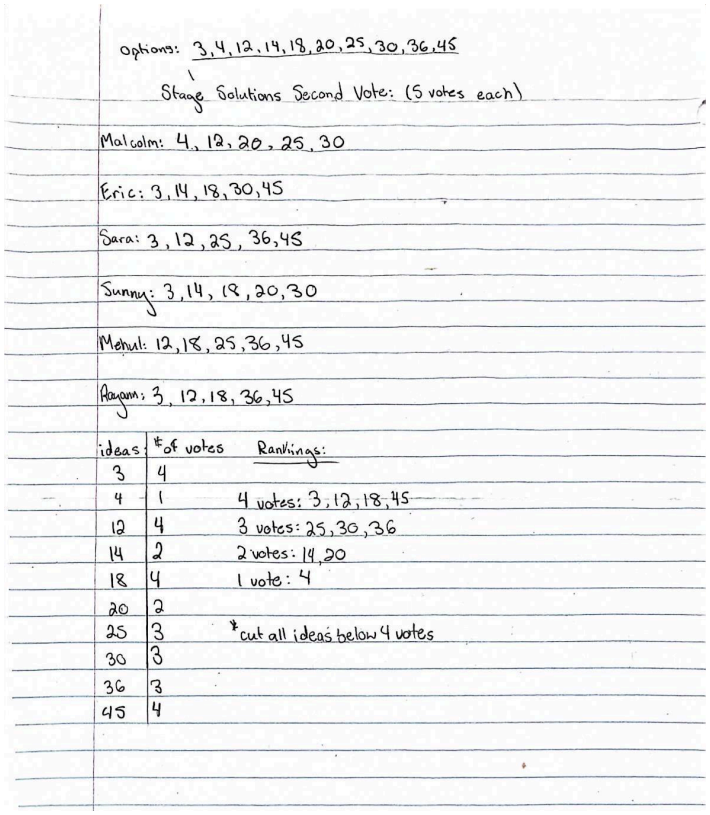
Mehul: 86, 87, 88, 97, 98, 99

Rayann: 82, 86, 87, 88, 98, 99

Sunny: 84, 85, 86, 93, 98, 99

idea	# of votes	Rankings:
82	3	6 votes: 86, 99
84	4	5 votes: 98
85	3	4 votes: 84
86	6	3 votes: 82, 85, 87, 97
87	3	2 votes: 88
88	2	1 vote: 93
93	1	
97	3	* cut all ideas below 4 votes
98	5	
99	6	

Figure 9. Multivoting on the 19 (both audience and stage) design ideas



Options: 3, 4, 12, 14, 18, 20, 25, 30, 36, 45

Stage Solutions Second Vote: (5 votes each)

Malcolm: 4, 12, 20, 25, 30

Eric: 3, 14, 18, 30, 45

Sara: 3, 12, 25, 36, 45

Sunny: 3, 14, 18, 20, 30

Mehul: 12, 18, 25, 36, 45

Rayann: 3, 12, 18, 36, 45

ideas	# of votes	Rankings:
3	4	
4	1	4 votes: 3, 12, 18, 45
12	4	3 votes: 25, 30, 36
14	2	2 votes: 14, 20
18	4	1 vote: 4
20	2	
25	3	* cut all ideas below 4 votes
30	3	
36	3	
45	4	

Figure 10. Multivoting (second round) on the ‘stage’ design ideas

This process left us with 12 design ideas (idea number: 3, 12, 18, 45, 57, 60, 64, 79, 84, 86, 98, 99)

Appendix H

Iteration process - morph chart. Used after the team cut down the ideas to 12. The following table lists 7 ideas for the audience seating solution and 7 for the stage solution. The 49 full system solutions are yielded from generating all possible combinations of the ideas listed in the chart.

	means	means	means	means	means	means	means
Safely enhance audience seating	(1) Mechanism to adjust space between rows	(2) Movable or portable seating	(3) Adjustable seating platform that can be raised or lowered	(4) Reserve zones for accessible seating	(5) Project performance on walls for 360° view	(6) Seats that retract to open up wheelchair space	(7) Mechanical chairs that shift from regular seating to platforms for accessible seating
Safely access to the stage/backstage	(1) Unfolding ramp	(2) Wheelchair lift	(3) Elevation device in pit	(4) Stair assistance technology (motorized stair climbers or lift assist devices)	(5) Flattened run-off from ramp at stage level which goes behind a wall that leads to the stage	(6) Pulley system connected backstage that pulls people with disabilities on stage	(7) Conveyer belt on an incline

Table 2. Morph chart of selected ideas for audience seating and stage.

Morph chart combinations (3 from each person) :

1. (1,2) - To make the wheelchair seating more accessible we will have a mechanism to adjust the space between rows and to allow the wheelchair users to access the stage safely we will have a wheelchair lift that has adjustable speed

2. (1,4) - Adjusting the space between rows and stair assistance technology installed which will use motorized stair climbers or lift assist devices

3. (5,3) - Performance is projected (or streamed on TV's) around the theatre, and disabled persons access the stage by an elevation device in the pit

4. (2,4) - Have movable seating to allow the audience seating to be more spacious, to allow disabled actors to access the stage have a flattened run-off ramp at stage level which goes behind a wall that leads to the stage

5. (4,1) - reserve zones for accessible seating throughout the theatre in accessible areas and have an unfolding ramp that will allow members to access the stage

6. (3,2) - To enhance the audience seating and access to the stage/backstage, there will be adjustable seating platforms that can be raised or lowered in the audience, as well as wheelchair lifts that will provide access to the stage/backstage.

7. (1,1) - Mechanism that can adjust the space between rows in the audience seating, as well as an unfolding ramp that allows access to the stage/backstage.

8. (5,5) - The performance is projected on the walls for a 360° view to enhance the audience experience, and there is a flattened run-off from a ramp at stage level which goes behind a wall that leads to the stage.

9. (4,5) - Zones are reserved for audience seating, and there is a flattened run-off from a ramp at stage level which goes behind a wall that leads to the stage.

10. (3,3) - To enhance the audience seating and access to the stage/backstage, there will be adjustable seating platforms that can be raised or lowered as well as an elevation device in the pit

11. (4,2) -Reserve zones for accessible seating.Wheelchair lifting mechanism, to access backstage

12. (2,3) Moveable or portable seating and elevation device in pit

13. (3,5)-Adjustable seating platform that can be raised or lowered.Flattened run-off from ramp at stage level which goes behind a wall that leads to the stage.

14. (5,1) -To safely access the stage there will be a flattened run-off area from the ramp at stage level which will go behind a wall that will then lead to the stage.
15. (5,2) - To safely enhance the audience seating experience the performance will also be projected onto the theatre walls
16. (1,6)- Mechanism to adjust space between rows along with a pulley system connected backstage that pulls people with disabilities on stage

17. (4,3) - A run-off ramp from the stage which follows a wall to the entrance ramp, and an accessibility seating zone will be reserved at the back of the theatre
18. (1,7)-Mechanism to adjust space between rows along with a conveyor belt on an incline to access the stage.
19. (5,4) - The performance will be projected onto the theatre walls and stair assistance technology will allow the users to access stage
20. (6,1) - Audience seating will include retractable seats that open up space for wheelchairs. To access the stage, an unfolding ramp will be implemented backstage
21. (7,2) - Audience seating will include mechanical chairs that can be pushed into the ground to allow space for wheelchair personnel. A wheelchair lift will allow those with disabilities to access both front and backstage
22. (6,3) - Seats that can move horizontally will open up space for wheelchairs, and an elevation device where the pit band plays will allow wheelchair users to access stage
23. (7,1) - Mechanical chairs that can transform into disabled seating will be in the audience, with an unfolding ramp to access stage
24. (6,2) - Moveable seats in the audience will make way for wheelchair users and a wheelchair lift will be added backstage
25. (6,4) - To enhance audience seating the seats will retract to open up wheelchair space and to access the stage there will be stair assistance technology (motorized stair climbers etc)
26. (4,6) - There will be reserved zones for accessible seating, as well as a pulley system connected to the backstage that pulls people with disabilities on stage.
27. (4,7) - There will be reserved zones for accessible seating along with a conveyor belt on an incline to safely access the stage.
28. (5,6) - The performance will be projected on the walls for a 360° view, as well as a pulley system connected to the backstage that pulls people with disabilities on stage.
29. (5,7) - The performance will be projected on the walls for a 360° view along with a conveyor belt on an incline to safely access the stage.
30. (6,6) - There will be seats that retract to open up wheelchair space, as well as a pulley system connected to the backstage that pulls people with disabilities on stage.
31. (6,7) - There will be seats that retract to open up wheelchair space and a conveyer belt on an incline to safely access the stage, as well as a conveyer belt on an incline to access the stage.
32. (7,6) - There will be mechanical chairs that shift from regular seating to platforms for accessible seating, as well as a pulley system connected to the backstage that pulls people with disabilities on stage.
33. (7,7) - There will be mechanical chairs that shift from regular seating to platforms for accessible seating, as well as a conveyor belt on an incline to access the stage.
34. (2,6) - Movable or portable seating along with a pulley system connected backstage that pulls people with disabilities on stage.
35. (2,7)Movable or portable seating with a conveyor belt on an incline to access the stage.

36. (3,6)Adjustable seating platform that can be raised or lowered with a pulley system connected backstage that pulls people with disabilities on stage.
37. (3,7)Adjustable seating platform that can be raised or lowered with a conveyor belt on an incline to access the stage.
38. (6,5) - seats that retract to open up wheelchair space will be used in the audience and a flattened run-off ramp at stage level which goes behind a wall that leads to the stage will be used for stage access
39. (7,4) - Mechanical chairs that shift from regular seating to platforms for accessible seating, Stair assistance technology (motorized stair climbers or lift assist devices
40. (7,5) - Mechanical chairs that shift from regular seating to platforms for accessible seating, flattened run-off from the ramp at stage level which goes behind a wall that leads to stage
41. (7,3) - For accessible seating mechanical chairs that shift from regular seating to platforms will be used, while for access to the stage, an elevation device will be used to take the mobility-challenged person from ground level to the stage.
42. (4,4) - For accessible seating specific zones will be reserved for wheelchairs, while for access to the stage motorized stair assistance technology will be used.
43. (1,3) - For accessible seating a mechanism will be installed to adjust the space between rows to make space for wheelchairs, while for access to the stage, an elevation device will be used to take the mobility-challenged person from ground level to the stage.
44. (3,1) - An adjustable seating platform that can be raised or lowered is used in the audience to have easily accessible seats and an unfolding ramp will be used for wheelchair users to access stage
45. (2,1) - For accessible seating movable or portable seating will be available for mobility-challenged guests, while for access to the stage, an unfolding ramp will be used.
46. (2,2) - There will be movable or portable seating, as well as a wheelchair lift for stage access.
47. (2,5)- For accessible seating movable or portable seating will be available for mobility-challenged guests, while for stage access a flattened run-off from the ramp at stage level will be used that goes behind a wall and then leads to the stage.
48. (1,5) - Adjustable spaces between rows allow more space for the physically impaired and a flattened offramp from the stage which connects to the theatre entrance will allow stage access for wheelchairs
49. (3,4) - For accessible seating an adjustable seating platform will be used which can be lowered and raised to make space for wheelchairs, while for access to the stage motorized stair assistance technology will be used.

Appendix I

This list of 49 ideas was multi-voted on, and then 18 ideas were inputted into the weighted decision matrix described in section 6.2.

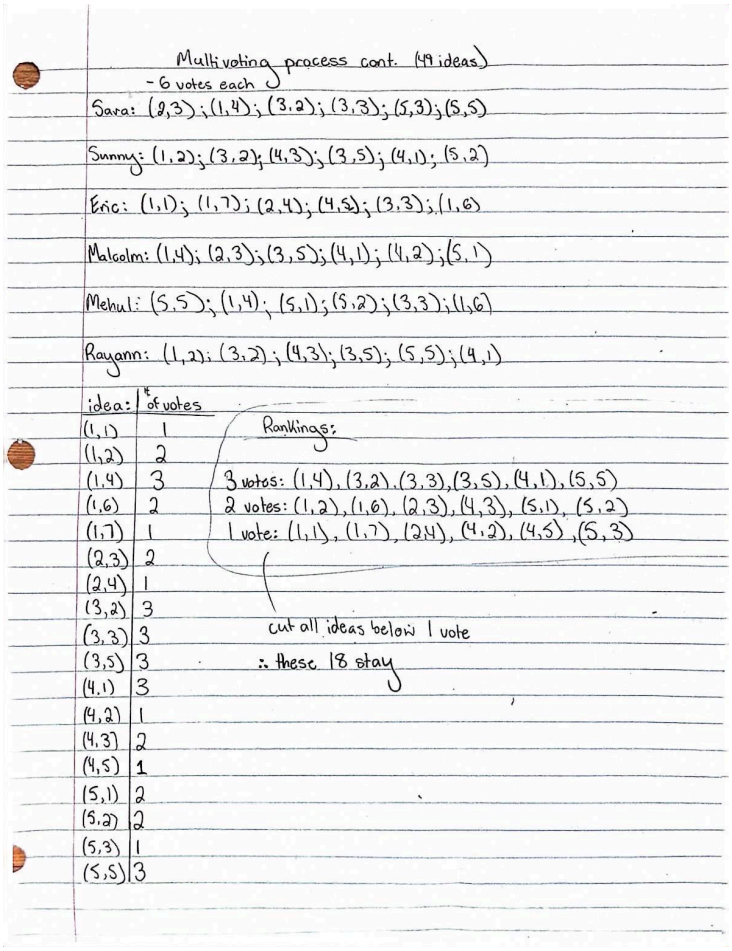


Figure 11. Multivoting on the 49 idea combinations.

Appendix J

The weighted decision chart was used to cut down our ideas to 10 so that we could use the recommended graphic decision chart method.

The percent values for the weighted decision chart were decided via a pairwise comparison chart

GOALS:	Follow codes	Usability	Durability	Non Disruptive	Scores
Follows codes [7,8]	X	1	1	1	3

Usability	0	X	1	1	2
Strength	0	0	X	1	1
Non-Disruptive	0	0	0	X	0

Table 3. Objectives Pairwise Comparison Chart

Objectives rankings reasoning:

- The following code is the most essential part of the project. If theatre is not brought up to modern codes, it would not pass inspection and may be deemed unfit for use
- Usability was placed second as wheelchair access is what we've scoped the project to. Ensuring that wheelchair users feel comfortable in the space and can use the design as intended is integral
- Durability is important but is not as important as the design being usable and the design following the law
- The design not disrupting the visual and audio space of the theatre matters, but the functionality of transporting the mass of the wheelchair user is more important

All ideas above the score of a 7.0 after summing the values of the chart are as follows (no particular order):
2, 4, 5, 6, 10, 12, 13, 14, 17, 18

Appendix K

Scale for evaluating each solution against the objectives:
0% - does not meet objective at all
20% - meets objective weakly
40% - meets objective somewhat
60% - mostly meets objective
80% - meets the objective strongly
100% - outstanding with respect to the objective

	1	2	3	4	5	6	7	8	9
Safety	7	8	7	8	8	8	7	7	7
Usability	9	9	7	8	8	7	7	7	6
Strength	5	9	8	7	6	7	4	6	8
Non-disruptive	3	9	2	9	7	9	7	6	5

Score	6.8	8.6	6.7	7.9	7.5	7.6	6.4	6.7	6.7

Table 3. Weighted decision chart

	10	11	12	13	14	15	16	17	18
Safety	7	5	10	6	7	6	8	9	9
Usability	8	7	8	8	9	8	4	9	8
Strength	7	6	9	7	6	6	9	5	9
Non-disruptive	5	8	10	8	9	6	4	5	2
Score	7.1	6.1	8.3	7.0	7.3	6.6	6.6	7.8	8.0

Table 4. Weighted decision chart continued

From Table 6 it is evident that the top 10 ideas are 2, 4, 5, 6, 10, 12, 13, 14, 17, 18.

Appendix L

Idea #2 description (row adjustment and wheelchair lift)

Audience Solution:

Remodelling existing theatre seats to meet standard safety regulations and adding a mechanism to adjust the space between rows of seats to create accessibility seating as needed. (see figure)

How it meets functions:

The primary function of the design is to facilitate the actors in entertaining the audience. The secondary function that emerged from this was cultivating an audience space which supports audience members of all mobility ranges. As it stands, the current theatre seats are at a 13-degree angle, exceeding the accessibility guidelines code [14]. To address this concern the seating area of the theatre will be remodelled to ensure the current seats create less than a 3-degree incline with the horizontal. The chairs will be designed to be ergonomic and have an optimal height of 43 cm and a width of 53cm [20]. In order to be accessible to wheelchair users and individuals with mobility issues, every other row of seats will have a mechanism to adjust the space between the rows. This mechanism will allow wheelchair users to sit in their preferred area by asking a Hart House staff member to increase the space between their preferred row and simply roll their wheelchair into the seat of their choice. Through this mechanism, the secondary function of supporting audience members of all mobility ranges can be accomplished.

How it meets objectives:

The design meets the safety metrics and goals by following all the Ontario building code specifications as well as Chapter 19 in the Ontario Human Rights Code. The design will be 53 cm wide and have 43 cm of height above the floor, falling well within the specific guidelines. The design meets the usability objective because it will be able to hold 262 kg of weight. However, the design may take more than 2 minutes to operate depending on how busy the theatre will be. The design will meet the strength objective as it will not require regular maintenance. Lastly, the design will also be non-disruptive as it will not produce 35 dB of sound. This is because it will use a hydraulic system that will create no more than 20 dB of sound [12]. Furthermore, it will allow all other functions of the facility to continue as it will only impact the amount of available seating in the audience.

How it meets constraints:

The first constraint regarding theatre seating is that "the design must include accessible and adaptable seating [5]". As the mechanism to increase space between rows supports the needs of disabled individuals, it meets this constraint. The next constraint is that the design "shall be operable with one hand". The mechanism to physically increase the space between rows is a hydraulic system that will be connected to a control panel allowing the operator to press a switch in order to begin the movement. As the design relies on a simple user interface, it meets this constraint. As the design does not alter the height of the rows, which are at an incline, the design also meets the constraint of "does not obstruct the view of the user or other persons". Lastly, as this mechanism only applies to every other row, it complies with the constraint that "seating must be in place next to the disabled seating to allow someone to aid their exit out of the building".

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Stage Solution:

The stage access component of this solution involves installing a motorized inclined platform lift backstage that will lift wheelchair users up from ground level to stage level. This will replace the small set of 2 black stairs. The new access will be for disabled persons' use only, as there are two other entrances for able-bodied performers [Harthouse video].

How it meets the functions:

The primary function of the design must be to facilitate the performers in entertaining the audience. For the performers to entertain the audience, the performers must be able to actually get on to the stage and this design facilitates that by providing a method for performers of all mobility ranges to get on and off the stage when they want to, thus also meeting the secondary function of facilitating performers of all mobility ranges.

How it meets objectives:

This design meets the objectives as it will follow city codes by making the motorized system less than 1800 mm in width, eliminating the need for any incline by using a lift, and will also have handrails to achieve the related city codes. The design will also meet the objective of having good usability by being easy to access and operate and will allow space for a wheelchair and accompanying person. The design does not have perfect security and durability, however, due to the mechanical stair climbing technology being involved in the lift which can be unreliable at times. The design will not be able to meet the non-disruptive design objective since the lift system can be louder than 35 dB, the design will also permanently block off a passageway for normal Harthouse work so it does not allow all functions to continue as normal.

How it meets constraints:

The first constraint regarding the theatre in reference to the design is its weight capacity, which will be achieved by using a lift platform with a weight capacity above 600 lbs. The design will include proper signage for guests which meets the constraint requiring proper signage. The lift platform system ensures that there is no need for an incline for mobility-challenged individuals to access the stage so it also satisfies the constraint relating to the incline angle for ramps. The constraint “The design must not be less than 900 mm in width” will also be satisfied by keeping the lift platform’s width within 900 mm. The design will also be operable with only one hand, meeting that constraint. The design will also blend in with the theatre aesthetic by keeping the same colour scheme and not obstructing the audience’s view, the design, however, will not be able to keep within 60 dB of sound The design will also not keep within fire safety constraints as it blocks a potential egress point.

Overview of how the entire design meets objectives shown in table _

Objective	**Justification**
Safety	Follows all applicable safety objectives including being accessible and having adaptable seating, being next to a fire exit, and having seating next to disabled seating to allow someone to aid their exit out the building. Designs for both audience and stage will meet the required measurements.
Usability	Holds a minimum of 363 kg and provides ample friction to prevent slippage. Both designs will be operable with one hand
Strength	Permanent solution, withstands 3000 PSI as industry standard stair climbing device.
Non-disruptive design	The seating solutions will not exceed the 35

	dB noise level and will not obstruct the other functions of the theatre. The motorized seating will exceed 35 dB and may obstruct the other functions of the theatre.

Table _: Objectives and justification of design option 1

Appendix M

Idea #6 description (Platform and Wheelchair Lift)

To enhance the audience seating and access to the stage/backstage, there will be adjustable seating platforms that can be raised or lowered in the audience, as well as wheelchair lifts that will provide access to the stage/backstage.

Relevant Research Questions:

- What materials will be used?
- What angle will the platforms be lowered to?
- How will the platforms be able to function?
- What will be the dimensions of these platforms?

Audience Solution:

- Currently, the slope in the audience seating is at an incline of 13° which is against city codes for inclines [14]. This idea involves electric powered seating platforms in the audience section that can be raised up and become leveled out, and then be lowered down to an appropriate angle of 3.5°, which allows the audience at the back of the platform to see the stage (see figure 12). These platforms will be built on top of the existing ground, located at the back of the theatre (see Figure 13). Regular seats in the designated areas for the platforms will be removed. The surface of the platform will be made of rubber to increase friction, which will decrease the chance of sliding. There will be sections on these platforms that have additional adjustable platforms that will be reserved for those on wheelchairs.

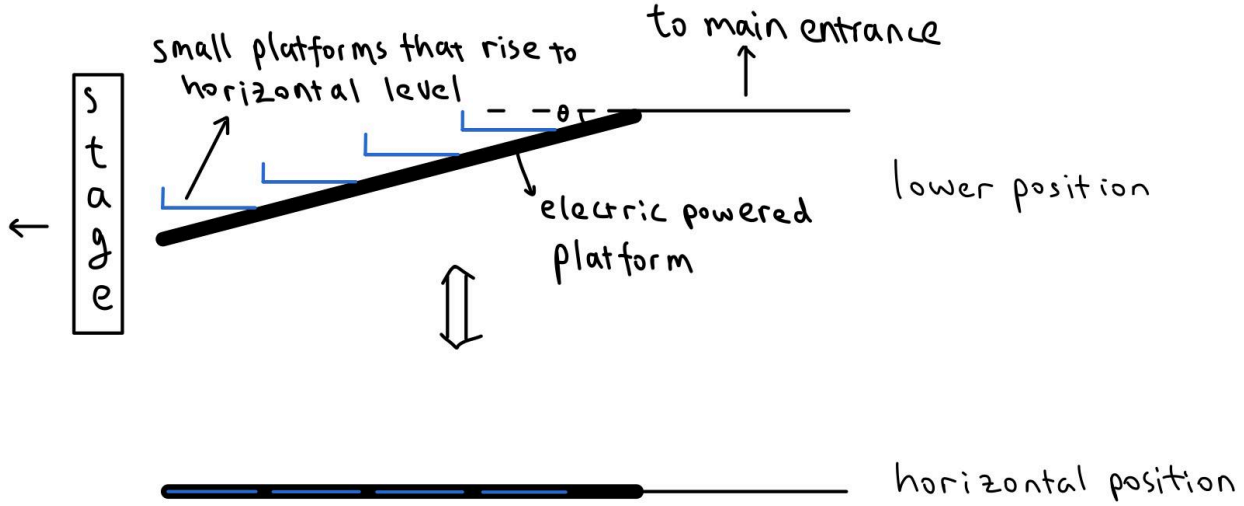

Figure 12. Demonstration of the side view of the "platform" design for audience solution.

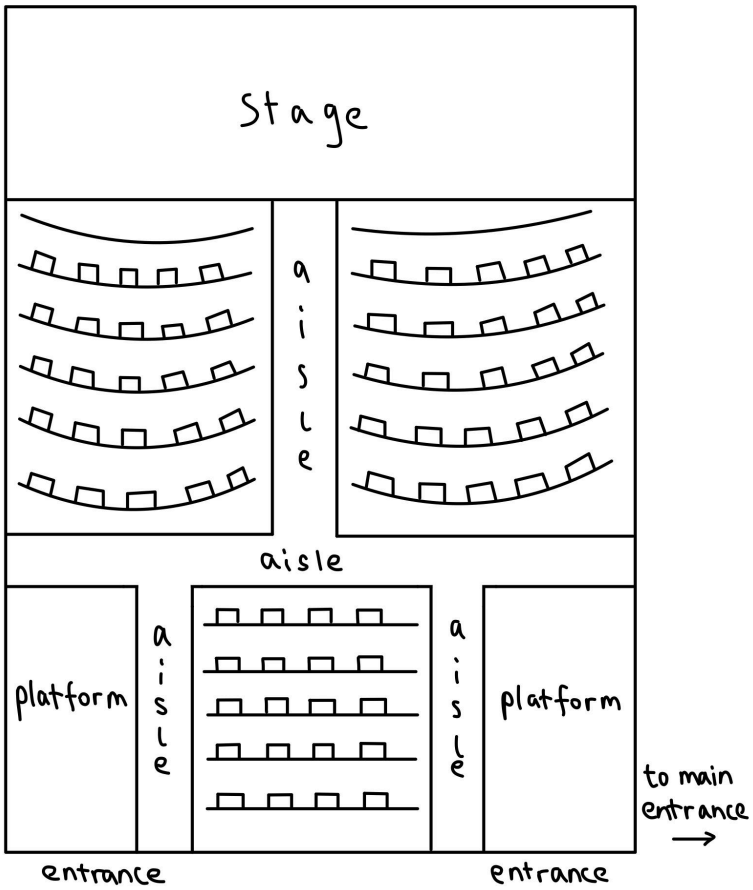

Figure 13. Location of the platforms in the Theatre.

How it meets the functions:

- The primary function of the design must be to facilitate the performers in entertaining the audience. In order for the audience to be entertained, they must be able to see the performance, therefore these platforms will facilitate the audience in viewing the stage comfortably. This idea also fits the secondary function of being able to seat audience members of all mobility ranges. People with limited mobility (people on wheelchairs or mobility scooters) will be able to access these platforms and see performances. Furthermore, audience members of all mobility ranges will be able to enter and exit the theatre through the main door.

How it meets objectives:

- The platform is designed to have a maximum incline angle of 3.5°, which satisfies the Ontario Building Code [9]. The platform also has sufficiently large space for at least 5 average wheelchairs. In terms of usability, the platforms are located near the entrance of the Theatre, enabling easy access to audiences with mobility challenges. The system is electric powered and will be controlled by buttons, which means that the rising and lowering mechanism is accessible. The platforms will be built upon the existing floor of the Theatre, so it meets the objective that no other functions of the facility will be disrupted when the design is in use. For durability consideration, the unit is expected to function well with little maintenance required, as it is not likely to be used frequently. Finally, the platform will be painted in dark red to match the overall aesthetic style of the Theatre, which satisfies the objective of being non-disruptive.

How it meets constraints:

- This design will meet the following constraints. It will not hold less than 600 lbs, it will include accessible and adaptable seating, it will include proper signage to indicate the purpose of the design, it will not be less than 900 mm in width, it will not obstruct the view of the user or other persons, and lastly it will not conflict with the Ontario Fire Code, or Fire Protection and Prevention Act of Ontario.

<u>Stage Solution:</u>

- For the stage and backstage part of the solution, this idea proposes to install a wheelchair lift. The wheelchair lift will be implemented to the staircase in the backstage. The staircase that will be used is shown in Figure 14. The user will be assisted onto the lift and lifted up the stairs into the backstage.

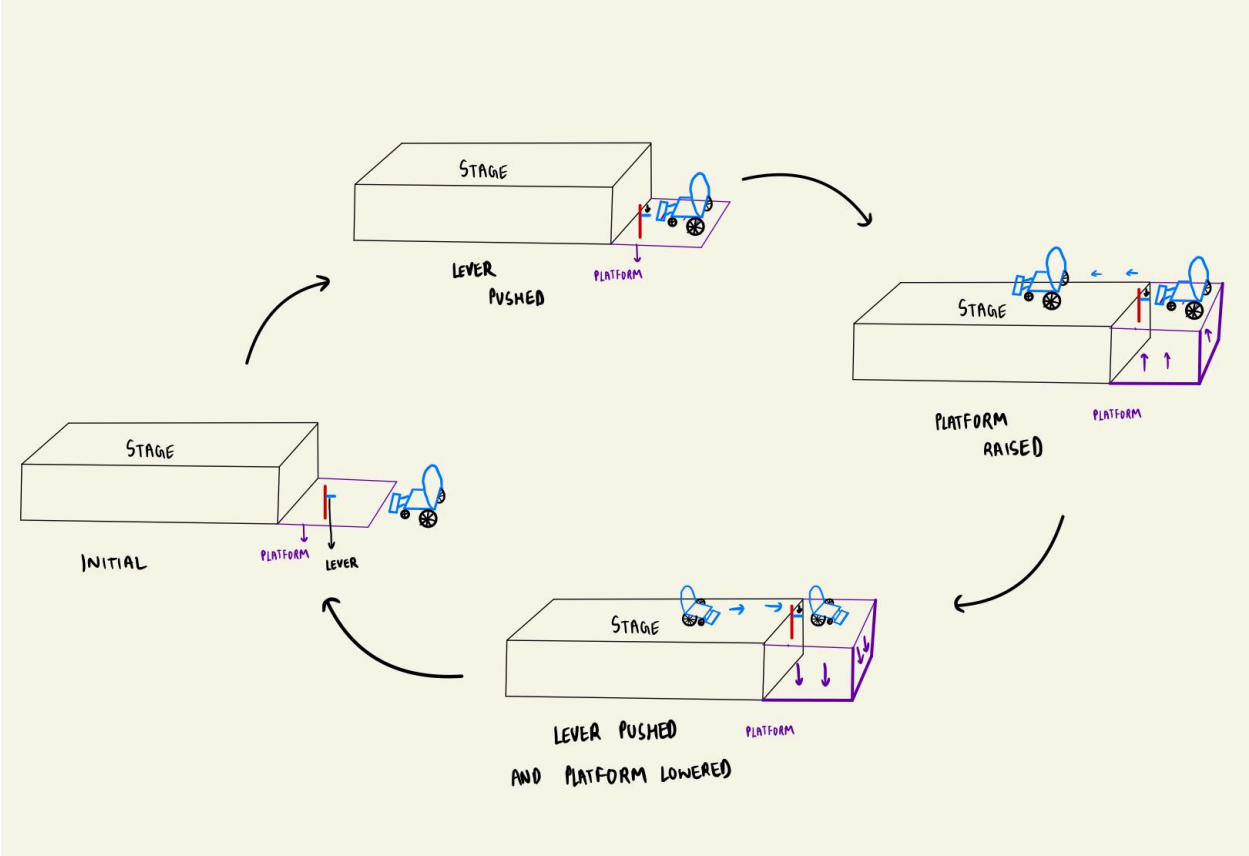

Figure 14. Wheelchair lifting mechanism.

How it meets the functions:

- The wheelchair lift will meet the primary function of facilitating the performers in entertaining the audience. This is achieved by allowing persons with limited mobility to reach the stage, allowing them to perform and entertain the audience. It will also meet the secondary functions of transporting actors of all mobility ranges onto the stage from the backstage through the assistance of the lift, as well as the function of transporting them off the stage and into the backstage.

How it meets objectives:

- This design will meet the objectives of safety because all applicable safety codes will be met such as fire codes, as well as having disabled seating next to regular seating so that aid can be provided in moving disabled persons out of the theatre. It will meet the objective of usability because the design will be efficient and compatible with users of all mobility ranges. Furthermore, it will withstand 363 kg, and it will take less than 2 minutes to reach the stage from backstage. It will not meet the strength objective because both the wheelchair lift and platforms will have many parts to it, as they are highly technological, thus it will be more likely for malfunctions to occur. Therefore, the strength of the design is low relative to designs that have little to no maintenance, such as

a ramp. Lastly, the design will not fully meet the objective of being non-disruptive. This is because while the wheelchair lift is incorporated into the staircase, the flow of people will not be disrupted while the lift is not in use, as people can still access the stairs. The adjustable platforms will disrupt the flow of people because people will need to wait for the platforms to rise and everyone to go to their seats before the platform can be lowered.

How it meets constraints:

- This design will meet the following constraints. It will not hold less than 600 lbs, it will include proper signage to indicate the purpose of the design, it will not be less than 900 mm in width. It will comply with the Technical Standards and Safety Authorities regulation on elevation devices, and lastly it will not conflict with the Ontario Fire Code, or Fire Protection and Prevention Act of Ontario.

Overview of how the entire design meets objectives is shown in table _

Objective	**Justification**
Safety	All applicable safety codes will be met such as fire codes, as well as having disabled seating next to regular seating so that aid can be provided in moving disabled persons out of the theatre.
Usability	The design will be compatible with users of all mobility ranges. It will withstand 363 kg and it will take less than 2 minutes to reach the stage from backstage.
Strength	Both the wheelchair lift and platforms will be primarily made of stainless steel. Stainless steel is an extremely strong material, as it can withstand approximately 1560 MPa or 226259 psi [19].
Non-disruptive design	The wheelchair lift will not disrupt the function of the stairs as they can still be accessed. However, the adjustable platforms will disrupt the flow of people because people will need to wait for the platforms to rise and everyone to go to their seats before the platform can be lowered.

table _ : Objectives and justification for design option 2

Appendix N

Idea #17 description (new seating area and run-off ramp)

Audience solution; meeting FOC's:

How it meets functions:

- This design meets the following secondary functions: seating supports audience members of all mobility ranges, audience members of all mobility ranges can enter and exit the theatre through the main doors. With this design, the seating would be closer to the theatre's entrance and there would be no incline between the seating and the exit.

How it meets objectives:

- This design meets the objectives as it will follow city codes by using the top space of the theatre to provide wheelchair-accessible seating for at least 5 average (25×32 inches) wheelchairs, it also has good usability by breaking down the back wall which will make the space easy to access and operable for persons with disabilities, has good durability as it is a permanent design which will require little to no maintenance and have no operational cost, and will be a non-disruptive design as it does not produce sound, fits into Harthouse's aesthetic features and allows for all other functions of the theatre to continue when in use.

How it meets constraints:

- To meet the accessibility guidelines constraints, the design will be at least 3.7m in length and 900mm wide to accommodate 5 wheelchairs[14]. Signage will be posted at either end to communicate the purpose of the design [15]. This design abandons the current two accessible seating locations, as they both can only be accessed by the 7° incline ramp which violates the constraint and code on ramp inclines (3.81° max).

Stage Solution; meeting FOC's:

How it meets the functions:

- The design follows the primary and secondary functions as it is able to transport actors of all mobility ranges to and from the stage, and it facilitates the entertainment of the audience by being non-obtrusive and provides a more inclusive performance.

How it meets objectives:

- This design meets the objectives as it will meet all city accessibility codes; the ramp will have an incline of less than 3°, the hallway will include graspable handrails and sufficient lighting on the ceiling. The floor will be made with a concrete foundation which will be able to hold over 800 lbs and provide sufficient traction for wheels. The ramp is durable as. The design will be non obtrusive, as the doors will cause minimal noise and will be operable by the press of a button on the wall, with sufficient signage to indicate the design's purpose. The walls will be painted the same colour as the rest of the theatre walls to blend in. Moreover , since it is weak under tensile forces , the ramp is reinforced with steel at the base which has a high capacity to handle tensile stresses.

How it meets the constraints:

- The design will meet the safety constraints by being less than an incline of 1 inch ascent for every 15 inches travelled, the hallway will be greater than 900mm in width, and will be able to support more than 600 lbs at every point throughout. The design will meet the obstruction constraints by not being between the audience seats and the stage, and the outside of the hallway being painted the same colour as the theatre walls. The fire safety constraints will be met as there are no added obstructions between the wheelchair person and the theatre exit.

Overall Constraints met:

1.The design must not be inoperable with one hand

1.The design must not hold less than 600 lbs

2.The design must ensure that persons with disabilities are not discriminated against, in alignment with the Ontario Human Rights Code

3.The design must comply with the Technical Standards and Safety Authorities regulation on elevation devices

4.The design must have proper signage to indicate the purpose of the design- We put the accessibility stickers on the doors to show this

5.The design must not exceed a maximum incline of 1 inch ascent for every 15 inches travelled (3.81°) - It is a flat ramp

6.The design must not be less than 900 mm in width

7.The design must not have less than a 2.788 m^2 level area at either end

8.Does the design obstruct the view of the user or other persons

Overview of how the entire design meets objectives shown in table format:

Objective	**Justification**
Safety	The design follows all applicable safety codes (building codes, fire safety). The ramp incline is below 3.0°
Usability	The designs will hold a minimum of 363 kg and will provide ample friction to prevent slippage. Both designs will be operable with one hand
Strength	Concrete can handle stresses from 2500- 4000 psi.
Non-disruptive design	The design produces less than 35 db of sound, doesn't block the audiences line of sight to the

	stage, and blends in with the rest of the theatre

table _: Objectives and justification for design option 3

Appendix O

Pugh Chart	Option 3	Option 1	Option 2
Safety	S	0	-1
Usability	S	-1	0
Strength	S	1	-1
Non-disruptive	S	-1	-1
SUM	0	-1	-3

Table 5. Pugh chart

Safety:

- Option 1:
    - staircase assistance is safe because it has been tested before and is commonly used in industries to support accessibility. It also follows all safety regulations and measurements.
    - row adjuster is seen as equally safe because the rows can be adjusted before the audience enters the theatre by the staff members, reducing the chances of an accident
- Option 2:
    - The wheelchair lift is relatively safe as it abides by all safety regulations according to the Ontario Building Codes
    - platform requires all audience members to stay in their seats while it changes the elevation of each seat simultaneously to face the stage. Since there are many moving parts in this solution, it was seen as less safe

Usability:

- Option 1:
    - Staircase assistance is usable because it is able to hold a minimum of 363 kg, however, it may take longer than 2 minutes to transport the wheelchair user to the stage
    - The row adjuster is able to support the required weight of the audience members and is an appropriate width to accommodate individuals of all sizes. The row adjuster will need to be operated by Hart House staff and will require a

wheelchair user to notify staff of their needs before or at the start of the performance. The entire process may take upwards of 5 minutes which is more than the 2 minute threshold

- Option 2:
    - The wheelchair lift will be compatible with users of all mobility ranges and can hold the required 363 kg. It will take less than 2 minutes to operate
    - The platform is compatible with users of all mobility ranges and can hold the required 363 kg. It will also take less than 2 minutes to adjust the audience seating

Strength:

- Option 1
    - The staircase assistance device will not require maintenance and is built to have 3000 PSI resistance
    - Since the row adjuster only creates modifications to the current seats and increases the space between them, it is seen to be able to withstand years of wear and tear and can withstand the standard PSI for audience seating.
- Option 2
    - Wheelchair lift is made of stainless steel and withstands 226259 psi [19].
    - Platforms will be made of stainless steel and can withstand 226259 psi [19]. However, platforms will have a limited capacity to lift and may need to limit audience capacity.

Non-disruptive:

- Option 1 -1
    - Staircase assistance will exceed 35 dB and may obstruct other functions of the theatre as it will permanently block off a passageway.
    - The row adjustment device will not exceed 35 dB of noise and will not disrupt the other functions of the theatre. However, the rows will need to be adjusted before every theatre performance based on audience needs
- Option 2 -1
    - The wheelchair lift will not disrupt the function of the stairs as they can still be accessed.
    - adjustable platforms will disrupt the flow of people because people will need to wait for the platforms to rise and everyone to go to their seats before the platform can be lowered. This may create a disturbance if individuals arrive at the theatre late.

The final results show that Option 3, the datum, is the optimal design

Appendix P

The choice of design, as per the Pugh chart, centres on its permanent and convenient nature, ensuring non-disruptiveness and usability. Design option 3, once constructed, will offer a fully non-disruptive and low-maintenance solution. This is because the design will create a permanent new walkway for individuals with mobility issues to access the stage. Since a hallway does not need to be maintained and can be accessed at any time, it is not disruptive to the performance, to the users, and has permanence. Furthermore, this means that it also falls within the 35 dB noise constraint and will not interrupt the performance. These factors also make the design more usable and convenient for the target audience.

Similarly, the audience solution of tearing down the back wall to create an accessible seating zone is also a non-disruptive and usable solution. After the back wall has been removed, more space will be created to add permanent accessible seating. This seating will not disrupt the flow of people into the theatre and the existing function of the theatre, evident in the theatre floor plan (figure 14). Additionally, since this solution does not require the use of technology or other mechanisms to operate, it will be a noise-free solution, aligning with the 35 dB restriction.

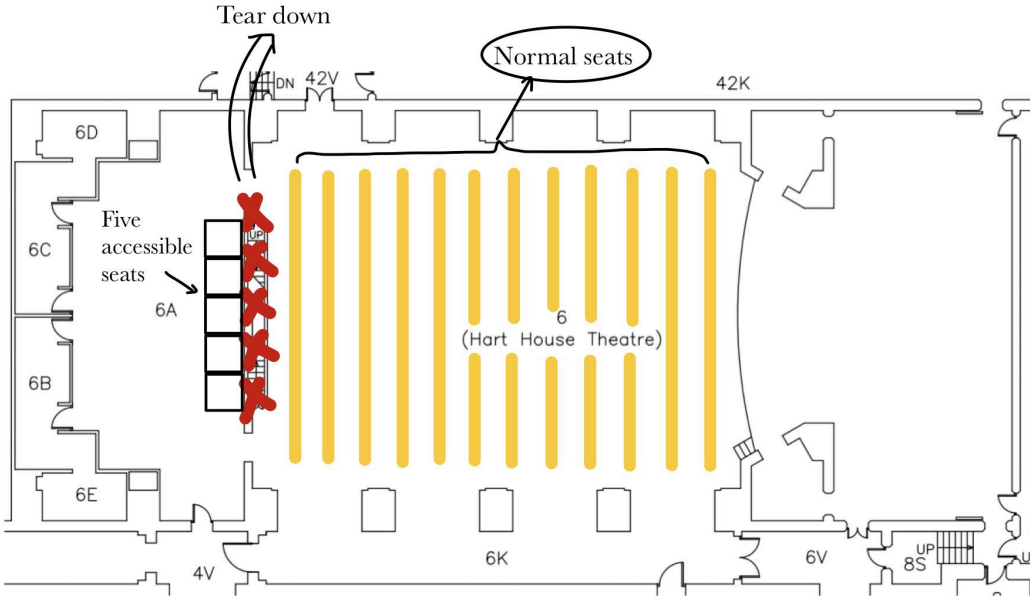

Figure 15. remodelled theatre layout

Therefore, design option 1 was proven to be the ideal solution due to being a permanent and convenient solution enabled by the objective of usability and non-disruptiveness,

Appendix Q

Other measures of success using the objectives of usability and being non-disruptive

Usability	Audience: Should hold minimum 363 kg [2] Stage: Should take 2 minutes or less to get from the main entrance of the seating area to the backstage	Audience: - Step 1: A weight of 363 kg will be placed on the seating platform to test how much force the platform can withstand. - Step 2: We will check if the platform can successfully hold the weight without breaking. - Step 3: If the platform successfully withstands the force, the platform is safe to use. Stage: - Step 1: Several wheelchair users will be brought in to test the ramp. - Step 2: A simulation will be run where wheelchair users move from the main entrance of the seating area to the backstage and this simulation will be timed to see if it takes less than 2 minutes. - Step 3: If it takes less than 2 minutes, that means the ramp is successful.

Non-disruptive	The design should produce less than 35 decibels of sound when in operation, and should not hinder the passage of other guests.	Audience: To make sure that the design with the wall torn down doesn't end up hindering the movement of other guests to their seats before breaking down the wall the section that will be turned into accessible seating will be closed off and guests will be told to enter and find their way to seats and the time taken will be measured using a stopwatch, after which the same test will be conducted without the proposed accessible seating area closed off, and then the time taken with and without the area closed off will be compared. If it is the same or less the design is successful in achieving the objective. Stage: After installation the sound produced by the design while a person in a wheelchair is using it will be measured using a decibel meter. If the measured sound level is below 35 dB then the design is successful in achieving the objective.

Appendix R

Attribution Table

Tutorial #:	121	Team #:	140
Assignment:	Conceptual Design Specifications	Date:	December 2nd 2023

The Attribution Table is a major resource used by your TA in determining whether there was equal contribution to the team assignment. If your TA determines that there was significant under contribution, then they may apply an individual penalty to the under contributing team members' grade. As a future professional engineer you should NOT sign any document you have not read and do not agree with.

The Attribution Table must be completed, signed by all team members, and included as an appendix of your assignment AND uploaded to your MS Teams team channel. Teams who do not submit a completed form, including those that submit an incomplete form, such as one missing a team member's signature, will receive zero on the assignment. The team may submit a petition to the ESP Office if they feel the lack of signature is through no fault of the team.

The Attribution Table should accurately reflect each team members' contribution to the document. Be sure to keep a copy of this form for the team's records.

If there are irreconcilable differences that are preventing all team members from signing the attribution table then each team member must write a letter (<one page) explaining their position on the difference and suggest a solution. These letters must be submitted to the TA.

As with any engineering statement this attribution table must be backed by credible evidence. In most cases this will be found either in the Google Docs document revision history, or your engineering notebook. Making fraudulent claims in an Attribution Table displays intent to deceive and is a serious academic offence.

Section	Student Names					
	Malcolm	Mehul	Eric	Rayyan	Sara	Sunny
Editing PR	✓	✓	✓	✓	✓	✓
Idea Generation	✓	✓	✓		✓	✓
Idea Selection	✓	✓	✓	✓	✓	✓

Alternative Design Solutions	✓	✓	✓	✓	✓	✓
Measures of Success	✓	✓		✓	✓	✓
Reducing word count			✓			✓
Introduction			✓			
Conclusion	✓					
Exec. Summary	✓	✓	✓	✓	✓	✓
ET	✓	✓	✓	✓	✓	✓
RS1	✓	✓	✓	✓	✓	✓
MR	✓	✓	✓	✓	✓	✓
FP	✓	✓	✓	✓	✓	✓

Fill in abbreviations for roles for each of the required content elements using the abbreviations found on the next page. You do not have to fill in every cell.

RS – Research (give details below) WD – Wrote Draft MR – Major Revision ET – Edited	FP – Final Proofread of COMPLETE DOCUMENT verifying for flow and consistency OR – Other (give details below)

If you put RS (research) please add a number identifier such as RS1, RS2, etc. Give the research question / topic:

RS1: Ontario Building Code along with other standards

RS2: _____

If you put OR (other) please add a number identifier such as OR1, OR2, etc. Explain the role below:

OR1: _____

OR2: _____

By typing your name below to sign, you verify that you have:

- Read the attribution table and agree that it accurately reflects your contribution to the associated document.
- Written the sections of the document attributed to you and that they are entirely original.
- Accurately cited and referenced any ideas or expressions of ideas taken from other sources according to the standard specified by this course.
- Read the University of Toronto Code of Behaviour on Academic Matters and understand the definition of academic offense includes (but is not limited to) all forms of plagiarism. Additionally, you understand that if you provide another student with any part of your own or your team's work, for whatever reason, and the student having received the work uses it for the purposes of committing an academic offence, then you are considered an equal party in the offence and will be subject to academic sanctions.

Student #1 Name	Malcolm	Student #5 Name	Eric
Student #2 Name	Mehul	Student #6 Name	Sunny
Student #3 Name	Sara	Student #7 Name	
Student #4 Name	Rayyan		