GNG 2101

# Design Project User and Product Manual

## Detachable Snow Plow


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# List of Acronyms and Glossary

**Table 1. Acronyms**

| Acronym | Definition |
|---|---|
| UPM | User and Product Manual |

**Table 2. Glossary**

| Term | Definition |
|---|---|
| Chassis | The general structure that holds all other components together, to the wheelchair. The black pipe construction seen in pictures of the snow plow. |
| Power shovel | An electrically powered device that shovels snow by using a motor-rotated disk to lift and propel the snow. |
| Snow plow/plough | Common short name/term for our product. |

# 1. Introduction

This User and Product Manual (UPM) provides the information necessary for disabled people to effectively use the detachable snowplow and for prototype documentation. Each part will present a unique perspective and provide information on the subsection's product.

The goal of our initiative is to allow people with disabilities the opportunity to conduct their own task and clear snow from their driveway. Wheelchair users typically like being outside and enjoy shoveling snow. However, because there is little to no commercial option, we created an alternate detachable snowblower for wheelchair users.

Our idea comprises of a snowblower that is connected to a wheelchair by pipes. A protective barrier is installed at the top to protect the user from the blown snow. Two shovels were positioned in front of the snowplow to maximize the surface area of the snow cleared. In addition, wheels were mounted to the snow plough to facilitate moving.

This user manual was created specifically for individuals who are using our prototype and solution since it describes how to use our snow plough as well as any considerations to take. This handbook will be divided into parts that will go into detail regarding our product. This manual will show you how each component was built or created to get the entire system operating together. You'll also see what we needed for each element in order to link it to the other. You will be shown how to use the system in detail, including how to set it up, access it, and leave it. There is a section with warnings and precautions that you should read before using the snow plough since some risk may arise. If an issue arises, there is a section that explains how to solve it, and if maintenance may be necessary. The bill of materials and the price of each component of the system are also included. Finally, testing techniques are carried out to ensure that the system is operational and ready to be handed over to the client.

## 2. Overview

The client requests a wheelchair with a detachable snowplough that allows the user to remove snow up to 12 inches from driveways while also shielding the user from the snow being removed. Using an electric snowplough or a shovel in front of the chair and leveraging the wheelchair's power is the way the final prototype is approached.

The customer desires a snowplough that can be connected and removed from the wheelchair and has a shield to protect the user from blowing snow. The snowplough should be capable of removing at least 8-10 inches of snow and should be able to work on a slope. The snowploughs should be motorised, and its electronics should be linked to those of the chair.
For a variety of reasons, our product outperforms many others. For starters, our prototype is constructed such that the user can move their legs, implying that the snowplough is not too near to the chair. This allows our user to position his legs and move them without being bothered by the snowploughed. Second, our design incorporates a barrier that protects the user and the chair's electronics from thrown snow. Third, our approach incorporates shovels that gather snow and direct it toward the snowplough, making it easier to remove the snow. Fourth, our user can operate the snowplough without the assistance of a third party, implying that he can run it by himself without the requirement for extra effort to push. That is why we included the wheels, to make moving the snowplough easier for the user. Finally, our electronics are shielded by a water-resistant casing, ensuring that snow or water droplets do not affect the user or the system.
The system must be linked to the wheelchair before it can be turned on. When the snow plough is linked to power, it will begin to function. To turn it on and advance it forward, use the black switch in the blue box. The mechanism will activate and begin clearing and blowing snow away. Depending on the direction of the wheelchair, the system can go forward or backward. As a result, there is no rotation or unique movement or direction in which the snow plough can go. The system cannot be used on rainy or snowy days because the electrical connections of the plougher may get damaged.


**Figure 1 - Final Prototype**

## 2.1. Conventions

During numbered and listed instructions (particularly during assembly), we have used asterisks to denote notes and/or tips on certain steps. These are typically optional actions, but may help in successfully completing the goal of the instructions.

## 2.2. Cautions & Warnings

Before utilising the system, the user should be aware of specific precautions or warnings. The user should be cautious of the wind direction since the snow may drift in their direction, damaging the snowplough connections. Furthermore, blowing snow at a high angle in windy conditions will almost certainly produce snow to fly upon the user at a height the shied cannot

stop. The user should also be cautious of the standard electrical warning and how the power shovel rotates, since they might cause significant injury to someone if the user drives into them. Furthermore, the user snowplough might be useful on a small angle of slope. However, if the slope was steep, the snow plough and wheel chair may slide and tumble due to the thick snow and ice that had developed. If the blue box, which is the plow's electrical box connected to the wheelchair, is exposed to extremely low temperatures, it may be crack or break. Furthermore, the box is water resistant, which means that water droplets can fall on it without damaging it or the electrical components within. However, if a lot of water was splashed on it, it may be ruined, causing the electrical that connects the snowplough to the wheelchair to be spoiled.

# 3. Getting started

The detachable snow plow is design for easy storage, so this entails that the whole thing can be taken apart into 3 main components: the snow blower, the chassis, and the shield assembly. Before even attaching to wheelchair, make sure that all the 3 main components are connected and secured. The chassis connects to the snow blower at 4 points as in figure (#). The chassis bolts to both sides of the snow blower. There are 2 slots in the middle pipe of the chassis where the handle connectors slide into preventing the chassis from rotating about the 2 blots mentioned earlier. It is curial to ensure that the two handle connectors slide all the way into the slots, and that the two bolts in front are fastened down. The shield assembly consists of 2 pipes, one acrylic sheet, and 4 nuts and bolts. Slide the acrylic shield into the two longitudinal slots in each pipe and align the holes in the acrylic sheet and the pipes. After aligning the holes, insert a nut in each hole and securely fasten it on the other side. Once the shield assembly is constructed, it is then attached to the chassis. The two pipes of the shield assembly should fit perfectly fit into the top "Y" fitting on both sides. Make sure to push hard to ensure a secure and sound connection. If not already bolted down, the two shovels should be secured at the front end of the snow plow such as in figure (#). They are secured with two bolts and two nuts.

After the snow plow is assembled, it can then be attached to the wheelchair. The snow plow is attached to the wheelchair with four pipe-clamps. The snow plow has four designated holes at the front two pipes where the clamps should sit in. The clamps should wrap around the footrest L-rod on the wheelchair and fastened, preferably with a screwdriver to decrease needed time to fasten. The electric box has two Velcro straps, providing the freedom of the user to secure the switch wherever they prefer. After ensuring that everything is safely secured, it can finally be plugged into the socket.

## 3.1. Set-up Considerations

As mentioned earlier the snowplow is made up of multiple components, so the main thing to consider while setting up is that all the components are securely connected together, and that the entire device is sound. To achieve optimum clearance height, make sure that the snow blower opening is slightly above the ground, just enough to allow the wheels to rotate. While in operation it is advised to keep the electric cable behind the user to avoid any tangling. When setting up the side shovels, make sure that they are in the correct orientation and angle to funnel snow into the snow blower as intended.

## 3.2. User Access Considerations

The product is mainly intended for wheelchair users, more specifically for our user's wheelchair dimensions. The product can be used normally by anyone as a normal snowplow, but we do not advice using it in that manner.

The main restrictions are that the design is mainly tailored to our user's wheelchair dimensions and our user's needs, so it might render it completely useless to other users if their wheelchairs have different dimensions.

The user will require someone to help them in attaching the snow plow to the wheelchair and changing the funnel direction and angle. If the snow plow is kept somewhere elevated or somewhere the wheelchair cannot directly access, they will require a helper to bring the snow plow to them.

## 3.3. Assembling the Snow Plow and Attaching to wheelchair

To access the detachable snow plow make sure that surrounding area is clear for easy access. Firstly, as mentioned earlier, make sure that all the components are assembled. After checking that all the connections are secure, the snowplow may now be strapped to the wheelchair. It is preferable to tighten the straps in a crisscross pattern. Starting at one of the top straps and then moving to the opposite bottom strap. This pattern ensures a tight fit throughout and limits any

possible damage to the wheelchair body. Once attached to wheelchair, use the Velcro straps to tighten the electronics box at desired position. Make sure that the switch is in the OFF position before plugging into power to avoid any accidental injuries. Once plugged in and ready, the user may switch to ON and start plowing snow.

## 3.4. Detaching the Snow Plow and Storing It

When the user has finished using the snow plow, he / she should turn the switch to the OFF position. After cutting the power, the user should park in a safe and a level plane before dismantling the snow plow to avoid it rolling down a slope. Once parked on a level surface, unplug the snow plow, and start loosening the 4 clamps preferably with the use of a screwdriver or socket wrench. Slide the clamps off the wheelchair and slowly move the snow plow assembly away from the wheelchair. To compactly store the device, remove the shield sub assembly from the chassis, and unbolt the chassis from the snowblower. Store bolts and nuts somewhere you can remember for future use.

# 4. Using the System

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the detachable snow plow.

## 4.1. Fastens to the Wheelchair

The chassis features ½" holes along the vertical side of the triangle, allowing for various fasteners to be threaded through. The snow plow itself comes with 4 gear clamps, already placed in the holes. The idea is to bring the fastener through the holes and around the hanging bars of the wheelchair, to fasten the snow plow to the wheelchair. The loose fastener and hole design allows for a variety of fasteners to be used. Once attached, the snow plow should remain on the wheelchair, when moving forward, backward, or turning.

### 4.1.1. Attaching to the Wheelchair

The exact steps for attaching the snow plow to the wheelchair are described below.

1. Bring the back of the snow plow (triangles) close to the front of the wheelchair.
2. Open or unfasten the fastener.
    * In the case of gear clamps, use a socket wrench (about 8 mm or 5/16") or flathead screwdriver to rotate the gear counter-clockwise until the clamp opens.
3. Thread the fastener through one of the pairs of holes along the vertical pipe of the triangle.
4. Bring the fastener around the hanging bar of the wheelchair.
5. Close and tighten the fastener.
    * In the case of gear clamps, bring the other end to the gear and use a socket wrench (about 8 mm or 5/16") or flathead screwdriver to rotate the gear clockwise until the clamp closes and tightens around the hanging bar.
6. Repeat steps 2-5 for all fasteners you are using.

### 4.1.2. Detaching from the Wheelchair

To detach the snow plow, simply perform the steps for attaching in reverse. Exact steps are given below.

1. Open or unfasten the fastener.

    * In the case of gear clamps, use a socket wrench (about 8 mm or 5/16") or flathead screwdriver to rotate the gear counter-clockwise until the clamp opens.
2. Bring the fastener out and away from the hanging bar of the wheelchair.
3. Optional: Close and tighten the fastener to prevent them from falling off.
    * In the case of gear clamps, bring the other end to the gear and use a socket wrench (about 8 mm or 5/16") or flathead screwdriver to rotate the gear clockwise until the clamp closes and tightens around the hanging bar.
4. Repeat from step 1 for all fasteners you are using.
5. Move the snow plow away from the wheelchair.

## 4.2. Shoveling Snow

The snow plow shovels snow by using the power shovel to throw snow out its funnel. Thus, using the snow plow is like using a power shovel or snow blower. Exact steps to shovel snow are given below.

1. Have a helper adjust the funnel to your desired direction and angle.
2. Plug in the electrical plug of the snow plow into an outdoor-grade extension cord that is connected to a power source.
3. Flip the switch into the ON state to turn the power shovel on.
4. Drive the wheelchair to move the snow plow. Move the snow plow towards and into snow. When the power shovel makes contact with the snow, the snow should be thrown out from the funnel.
5. Reverse, back up, and reangle yourself should you want to shovel snow directly next to you.
6. Turn off the power shovel and ask a helper to readjust the funnel should you want to change its direction or angle.

## 4.3. Attaching the Shield

Our design features a detachable shield for the snow plow. Being detachable allows the shield to be removed when not in use, for better storage. The shield can also be removed from its standing pipes, and tucked into a bag to keep it clean.

### 4.3.1. Attaching the Shield to its Standing Pipes

To attach the shield to the chassis, the shield must be first attached to its standing pipes.

1. Slide the pipe pieces onto the shield and align the holes in the pipe pieces with the holes in the shield.
2. Insert bolts through the holes and use nuts to secure the pipe pieces, shield, and bolt in place.

### 4.3.2. Attaching the Shield to the Chassis

Once on the standing pipes, the shield and standing pipes can now be inserted into the open fitting at the top of the chassis triangle.

1. Place the standing pipes of the shield on the open fittings at the top of the chassis triangle.
2. Push down on the pipes to lodge the pipes into the fitting. The pipes should be secure and not risk toppling easily.
3. If it is difficult to push the pipes down into the fittings, use a paper towel to wipe any dust or dirt off the pipe and fitting hub.

## 4.4. Disassemble the Snow Plow

Our simple design allows for easy disassembly of the snow plow, so long as you have a flathead screwdriver and an adjustable wrench. You may want to disassemble the snow plow for storage reasons, or if you need to examine and fix parts of the snow plow. The steps on how to disassemble the snow plow are given below. Steps on how to completely (re)assemble the snow plow can be found in Section 6.1.3.4.

1. Open the gear clamps or fasteners and remove them from their holes.
2. Remove the shield from the top of the chassis triangles by pulling the standing pipes out from the fitting.
3. Loosen and remove the nuts from the bolts fastening the snow shovel guides to the chassis. Remove the bolts and snow shovel guides.
4. Remove the nuts and bolts holding the front of the chassis to the front of the power shovel.
5. Slide the chassis off of the power shovel by lifting the chassis off of the power shovel's prongs.
6. Remove the nuts and bolts holding the crossbeam pipe between the two chassis triangles and remove the crossbeam pipe soon after.

# 5. Troubleshooting & Support

## 5.1. Behaviors

- If the power shovel does not turn on when the switch is set to the "ON" state while plugged in, check the soldered connections both inside and outside of the electrical box. You may also need to check that the wire is still connected to the power shovel. If any connection is broken, simply reconnect, resolder, and reapply electrical tape.
- With our current snow plow design, the shovels may break off the snow plow when subject to excessive push and/or pull forces. This is due to being secured with one bolt only, as well as the lack of washer. Add a washer between the bolt head and the shovel to reduce the risk of this issue.
- Should the gear clamps lockup due to the cold weather or ice, use a hairdryer to warm the gear clamps back up or melt the ice. If there is an emergency, and the snow plow needs to be removed quickly, the clamps can be cut using sheet metal cutters or similar heavy-duty cutters. The clamps can be replaced with many fasteners easily.

## 5.2. Special Considerations

- Make sure the toggle switch is set to the off state and the snow plow is off and unplugged when performing any sort of maintenance on or fixing the snow plow.
- The snow plow has not been tested against heavier loads, such as wet snow. As such, only attempt to shovel low volumes of heavier loads. You may shovel higher volumes of heavier loads at your own discretion (we cannot stop you), however we take no responsibility should the power shovel break because of it.

## 5.3. Maintenance

- The snow plow must be left in sheltered storage, and away from direct sunlight when not in use. The ABS piping used can deform when left in direct sunlight.
- Snow must be brushed off of the snow plow with any sort of snow brush after every use.
- Snow should be brushed off of the acrylic shield after use, and washed should salt or dirt begin to obscure the user's vision during use.
- The nuts and bolts of the snow plow and electrical box should be checked and re-tightened if needed, semi-regularly during the winter or use. The nuts and bolts should also be checked and re-tightened before use after leaving the snow plow in storage over non-winter seasons.

- The tape covering the solder connection should be checked semi-regularly, and replaced if needed.

## 5.4. Support

Users and those around them can contact us at the contact information listed below for emergency assistance or support on fixing the snow plow should any issues arise. When contacting us, please state your name and identify the situation. If you are contacting us on fixing the snow plow, please state what is visibly broken or what function of the snow plow has stopped working. During or after you contact us, we may make additional inquiries about the snow plow to get a better idea of the situation or problem. Please respond to these inquiries so that we may better assist you in fixing the snow plow.


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# 6. Product Documentation

There are many components to the prototype which fall under two main subsystems. The first subsystem consists of all of the mechanical features and construction, including the chassis, shovel guides, and shield components. This subsystem covers the core features of the snow plow: shoveling snow, protecting the user from blown snow, and providing the snow plow with structure so it may exist. The subsystem was constructed primarily in a workshop, with the tools for drilling and cutting available. However, cementing and sealing the ABS pipes together requires a temperate, well-ventilated area, and involves toxic chemicals ill-suited for public environments. Thus, cementing and sealing was done at home with proper preparation.

**Figure 2 - Angled View of Snow Plow**

The second subsystem is the electrical switch box, the only electrical component of the prototype. The power shovel needed to be rewired, as our user has difficulties with hand-coordination. Operating the power shovel alongside the wheelchair was not an option. Rewiring

the shovel and using a toggle switch has other benefits, including allowing the user to keep their hands warm and unoccupied, even if the user would be able to multitask with their hands. Our construction of the subsystem requires a 3D printer, but only for two parts. The rest of the construction only requires basic and available hand-tools, and as such, can be done in the comfort of one's own home.


**Figure 3 - Electrical Switch Box**

ABS pipe, the most prominent material in our prototype, was chosen semi-arbitrarily. ABS does offer a few advantages. It is quite cheap, and easy to use in construction. For those with only basic experience or training in construction work, this material is great when compared to metals which would require welding training. It is also stronger in the cold and has more available fittings when compared to PVC – a similar, but different material. It also lightweight and is not as cold to touch during the winter. For those with welding experience and a larger budget, metals that resist corrosion in cold weather could be tested. It would, in theory, offer a more rigid

construction and offer more flexibility in the choice of joints. However, it would cause the snow plow to increase in weight, and the chassis be more dangerous to touch directly during the winter.

The power shovel was chosen due to it coming with wheels, being of good width, and being on sale at the time. Similar power shovels could be sought after. Power shovels that are battery-powered instead of corded would offer better independency and mobility to the user, at the cost of price and risk of running out of power. Power shovels with wider clearing widths may allow the snow shovel guides to be removed from the design entirely. However, it would also likely cause a redesign in the chassis.

The choice of using a 3D printer and PLA filament came down to availability and ease of action. PLA is quite weak in the cold, so choosing a different material that is stronger in the cold would be an improvement.

The switch was chosen for its toggle properties, moderate resistance, and protective boot covering. The toggle properties allow those with hand-coordination issues to operate the snow plow's power shovel. The moderate resistance prevents accidental turn-ons or turn-offs, though those with lower strength may find it more difficult to operate. The protective boot protects the switch and internals from the snow and winter weather. Those looking for other advantages, such as a lower profile, or an easier time flipping the switch may try other switches. However, most switches are not protected against excessive snow, so a different protective cover may also be needed.

## 6.1. Chassis, Shield, and Shovel Guides

### 6.1.1. BOM (Bill of Materials)

**Table 3. BOM for Chassis, Shield, and Shovel Guides**

| Part Name | Description | Quantity | Unit Cost | Source |
|---|---|---|---|---|
| **ABS Pipe 12 ft (Large)** | Diameter: 2"<br>Length: 3' | 4 | $7.78 | Home Depot |
| **ABS Pipe 3 ft (Small)** | Diameter: 1 ½"<br>Length: 6' | 1 | $10.48 | Home Depot |
| **ABS Wye Fitting** | Fitting Size: 2"<br>Connections: All Hub | 4 | $3.96 | Home Depot |
| **ABS 90 Degree Elbow (Large)** | Fitting Size: 2"<br>Connections: All Hub | 2 | $3.45 | Home Depot |
| **ABS 90 Degree Elbow (Small)** | Fitting Size: 1 ½"<br>Connections: All Hub | 2 | $1.73 | Home Depot |
| **ABS 45 Degree Elbow** | Fitting Size: 2"<br>Connections: All Hub | 2 | $2.32 | Home Depot |
| **Oatey Cleaner / ABS Handipack** | Volume: 236 mL each | 1 | $12.20 | Home Depot |
| **Acrylic Sheet** | Dimensions: 24" x 12"<br>Thickness: 1/8"<br>Color: Clear | 1 | $13.00 | Makerstore |
| **SAE64 Metal Worm Gear Clamp** | Maximum Diameter: 4"<br>No webpage found for it. | 4 | $2.10 | Home Depot |
| **Yardworks Snow Shovel** | Clearing Width: 18"<br>Bought on sale. | 1 | $9.99 | Canadian Tire |
| **Paulin Round Head Square Drive Stove Bolts with Nuts** | Length: 2 ½"<br>Diameter: 3/16"<br>Amount per pack: 6 | 2 | $2.97 | Home Depot |
| **Greenworks 10-Amp 16-inch Power Shovel** | Type: corded<br>Clearing width: 16"<br>Clearing height: 6"<br>Amperage: 10 Amp<br>Same on as 6.2 BOM | 1 | $169.00 | Lowes |

### 6.1.2. Equipment list

- Hand drill (or equivalent for drill bits)
- Drill bits (sizes: #7 or 13/64 for our choice of stove bolts, ½ for our choice of fastener)
- Drill press (or equivalent for hole saw)
- Hole saws (sizes: 1 ¾, 1 3/8)
- Vice clamp
- Hack saw
- File
- Mill (optional alternative)
- Marker suitable for marking on ABS (or your choice of material)
- Measuring tape
- Flat screwdriver (for our choice of stove bolts)
- Adjustable wrench
- Scrap wood
- Human assistant
- Temperate, well-ventilated area.

### 6.1.3. Instructions

To simply the instruction, we will refer to two holes straight across of one another in ABS pipe as "a pair" of holes. We will also be referring to specific pieces of the cut ABS pipes with letters. These letters include A(cross), B(ridge), C(lamps), G(uides), H(ypotenuse), P(ower shovel), and S(hield). Below is a photo of the finished chassis, with markings of which piece is named which letter. Pieces mirrored across the power shovel share the same name (i.e., the two pieces connected to B are both named A).


**Figure 4 - Names of ABS Pipe Pieces**

#### 6.1.3.1. Chassis

7. Cut and file down the ABS pipes down to the required sizes.
    a. The stock ABS pieces need to be cut to the following sizes:
        i. For two 2" diameter, 3' long pieces, cut each stock piece into two 13.5" long pieces (A & C) and one 9" long piece (P).
        ii. For the other two 2" diameter, 3' long pieces, cut each stock piece into one 19.5" long piece (H) and one 16.5" long piece.
        iii. For the two 16.5" pieces obtained from the previous step, cut each stock piece into one 4" long (G), one 2" long, and one 10.5" long (S) pieces.
        iv. For the 1.5" diameter piece, cut the stock piece into on 20.25" (B) long piece (the rest will not be used).
    b. File off any loose chips and square the ends of your cut pieces.
8. Test your cut pieces with the pipe fittings. Ensure that pieces fit the fittings well, and that you can form the right-angle triangles with A, C, and H pieces. If any piece is too long, make the appropriate cuts or file-downs to fix them. If any piece is too short, you will likely need to buy more ABS pipe.

9. Cut a 1 ¾" hole for each A piece, to allow for piece B to bridge between the two triangles. The hole should be created at the centre of piece A, both lengthwise and widthwise.
10. Drill pairs of 13/64" holes, one for each A piece and one for each end of B, to allow bolts to hold the pieces together.
    * You can determine where the holes should be by fitting piece B into the holes (as deep as it can go) created in the previous step, and determining the approximate centre between the end of piece B and the edge of the hole in A. The point should be slightly off-centre to A widthwise.
11. Remove the handle and extension bars of the power shovel so only the two prongs by the wheels remain, if you have not already.
12. Cut two 1 3/8" holes in piece B to fit the prongs of the power shovel.
    * You can determine where along B and the angle the holes should be at by piecing the chassis together and fitting it to the power shovel.
13. Drill 13/64" holes, one pair for each P piece and two individual holes in the front of the power shovel, to allow bolts to hold them together.
    * You can determine where the holes should be by fitting the chassis (pieced together) onto the power shovel. The prongs of the power shovel should slot into the holes in B. The 45° fittings at the ends of P should just about clear the front of the power shovel. The holes should be close to the end of the power shovel, as high along the vertical black wall as possible. The pair of holes in P should, of course, align with the holes in the power shovel, or vice versa.
14. Drill one or more pairs of 13/64" holes into the G pieces to allow bolts to hold the shovel guides to the chassis.
15. Drill two pairs of ½" holes into the C pieces to allow fasteners to bind the chassis/snow plow to the wheelchair.
    * Hole location depends heavily on the wheelchair. For our case, our pairs of holes needed to be 1.5" from the bottom fitting, and 3.5" from the top fitting.
16. Cement all but the S pieces, together. Refer back to *figure* for an idea of each piece's position and orientation. Refer to the cement's safety and use instructions and make sure your surroundings are at a suitable temperature for the cement.
    * You will likely need someone else (a.k.a. human assistant) to help you when you cement the last pieces of the triangle (A, C, H) together.

#### 6.1.3.2. Acrylic Sheet Shield

1. Drill two pairs of 13/64" holes for each S piece to allow bolts to hold the shield to the S pieces. One pair should be ¾" from the end of the slit, and the other 1" from the first pair.
2. Make a pair of 2.5" long, 1/8" wide slits (across from each other), along the length of the pipe piece, perpendicular to the holes drilled in the previous step, for each S piece.
3. Drill four 13/64" holes in the acrylic sheet, one for each pair of holes in the S pieces.
    * The S pieces must hold the shield while sitting on the chassis' triangles. Use the chassis and the slits in the S pieces to determine where the holes should be.

#### 6.1.3.3. Shovel Guides

1. Cut 6" of the sides of the shovel off from the centre.
2. Drill a 13/64" hole in the side pieces of shovel about ¼ of the way down from the top, 2" in from the cut end.

#### 6.1.3.4. Complete Assembly

3. Insert B into the holes of both A pieces, using nuts and bolts to secure them together.
4. Slide the chassis onto the power shovel by sliding the prongs of the power shovel into the 1 3/8" holes in B.
5. Fasten the P pieces to the power shovel with nuts and bolts.
6. Attach the snow shovel guides to the G pieces by putting a nut and bolt through the back of the shovel piece, and through G.
7. Attach the acrylic sheet shield to the S pieces by sliding the sheet into the slits and fastening it with nuts and bolts.
8. Insert the S pieces into the open fitting hubs at the top of the chassis' triangles.
9. Insert the gear clamps through and past the holes in the C pieces. Close them if desired.

## 6.2. Electrical Box and Rewiring

### 6.2.1. BOM

**Table 4. BOM of Electrical Box and Rewiring**

| Part Name | Description | Quantity | Unit Cost | Source |
|---|---|---|---|---|
| **SERVALITE Toggle Switch** | Amperage: 10 Amp<br>Voltage: 125 V | 1 | $5.99 | Lowes |
| **Electrical Wire** | Type: SJTOW<br>Gauge: 14/2 or 16/2<br>Supplied by student. | 1 | N/A | N/A |
| **Velcro All Purpose Strap** | Length: 18"<br>Width: 1"<br>Colour: Black | 1 | $4.99 | Canadian Tire |
| **Machine Nuts, Bolts and Washers** | Diameter: 1/8"<br>Length: 1 ½"<br>A "unit" consists of 1 bolt, 1 nut, and 2 washers. | 4 | N/A | N/A |
| **3D-Printing PLA Filament** | Is free if used at uOttawa's MakerSpace | 1 | $40.00 | MakerStore |
| **Greenworks 10-Amp 16-inch Power Shovel** | Type: corded<br>Clearing width: 16"<br>Clearing height: 6"<br>Amperage: 10 Amp<br>Same one as in 6.1 BOM. | 1 | $169.00 | Lowes |

### 6.2.2. Equipment List

- Soldering iron
- Solder
- Location to solder in.
- Electrical tape
- Wire cutters
- Phillips-head screwdriver
- T20 screwdriver
- Hand-drill with bit size for the bolts
- Adjustable wrench
- 3D Printer
- Soldering helping hands (optional)
- Electric multimeter (optional)

### 6.2.3. Instructions

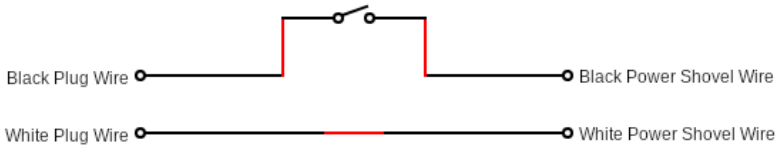
We have separated the section into two parts. The first is for rewiring the power shovel and soldering the connections. The second is for assembling the electrical box after rewiring and solder the power shovel.

#### 6.2.3.1. Rewiring and Soldering

1. Free the power shovel and plug wires from the power shovel's original electrical box.
    a. Start by opening the original, green electrical box of the power shovel. Unscrew the four T20 screws on the bottom side of the original electrical box. Be wary that parts inside of the box are held inside by the box, so certain parts may spring or jump out when you do open the box.
    b. Once open, remove the box from the power shovel handle by lifting the top portion away and sliding the bottom portion out of the holes of the handle.
    c. Now, with the box removed from the handle, unscrew (Phillips-head) and remove the clamps holding the 16/2-gauge wire of the power shovel. We reused these clamps and their screws in our design of the box, so be sure to keep the bindings and screws someplace safe.
    d. Next, remove all parts from the box, including the original push switch connected to the wires.

e. Unscrew the screw clamps on the switch to free the wires, and cut off the portion contained in the metal wire binding. Cut the wires attached to the slip-on connections to free up connection.

2. With the connections now free, set yourself up for soldering in a way so that you can solder the wire connected to the power shovel.
3. Solder the power shovel's wire to an additional wire to extend it.
    a. Start by cutting the outer jacket off of the bought 16/2-gauge wire. Make sure to keep the insulation and wire jacket, so that you may cover the soldered connection once you're finished.
    b. Solder the bought 16/2-gauge wire to the wire connected to the power shovel to extend the length, making sure that you solder the wires black to black and white to white to avoid confusion.
    c. Once finished soldering the two inner wires, cover each connection with electrical tape separately, to insulate the wires from each other.
    d. Use the removed jacket, removed insulation, and tape or any comfortable alternative (must resist cold and weather) to cover the taped connections.
    * Although you may use wire of any length for this extension, we recommend using 40 cm of extending wire on top of the original length.
4. Solder the plug, switch and wire of the power shovel together.
    a. Start by freeing about 5-6 cm of inner wires from the outer jacket and insulation, for both the plug wire and power shovel wire. Although we suggest this amount, we still recommend putting the wires and switch into the box and making sure you have enough length to make and keep the connections within the box.
    b. From there, assuming you are using a single-pole switch like us, solder the white neutral wires of the plug and power shovel together.
    c. Next, solder the black inner wire of the plug to one of the terminals of the switch. Solder the black inner wire of the power shovel's wire to the other terminal.
    d. Once again, wrap electrical tape around the solder connections to insulate and separate the connections from each other.
    * At this point, your circuit should reflect the following circuit diagram (the red represents soldered connections):



#### 6.2.3.2. Box Assembly

1. 3D-print the two parts of the box.
    a. The 3D printing files can be found on the MakerRepo repository of this project. Alternatively, you can create your own or make changes to our existing design. However, keep in mind that our design accommodates our listed parts.
    b. One beneficial and recommended change is to thicken the standoffs of the base of the box. Our design's standoffs were too thin and break when the T20 screws of the power shovel's original box to self-tap and thread into them.
2. Drill 4 holes about 1/8 inches in diameter through the lid and the standoffs of the box.
    a. Align the lid and the base of the box.
    b. Drill straight down through the lid (if holes are filled) and into the standoffs, all the way to the other side.
    * If you've thickened the standoffs, you can try using the T20 screws of the power shovel's original box to self-tap and thread into them.
3. Slide the Velcro straps through the slits of the box, from the outside-in and back out the other parallel slit. Make sure the burrs and wool face up in the box, or away from whatever they wrap around.
4. Use the Phillips-head screws taken from the power shovel's original electrical box (or similar) to self-tap and thread into the bottom side of the clamps in the box.
5. Fit the switch into its groove and line the inner wires in a comfortable manner of your choice.
    a. Take this time to remove any rings or protective boot off of the switch.
6. Clamp down the wires (outer jacket) to the box, using the plastic clamps and associated screws taken from the power shovel's original electrical box.
7. Put the lid on by putting the head of the switch through the hole in the centre of the lid. Put the protective boot or ring back onto the switch to secure the lid to the switch.
8. Put the 1/8-inch diameter, 1 ½-inch long bolts through the 4 holes of both the lid and the box.
    a. Put one washer on each side (one by lid, one by base) to prevent cracking.
    * If you've tapped with them successfully, you can use the T20 screws 9 of the power shovel's original box instead of the bolt-washers-nut combo.

## 6.3. Testing & Validation

Our final prototype was tested by attaching it to the user's wheelchair, and using it against snow that was shoveled onto the driveway, from the lawn. The prototype works at the core, however certain components had failed in intention. The power shovel remained on the wheelchair, and the power shovel did throw most of the snow as intended. However, the front of the power shovel was unable to make full contact with the ground, thus leaving a small layer behind as it threw snow. Thankfully, given optimal position settings of the wheelchair, this layer was reduced to a minimum, and the wheelchair was still able move through the snow, so long as it did not need to reverse uphill.

Due to poor construction, the snow shovel guides were not able to withstand the push and pull forces present during use. The shovel pieces were also not protected with a washer, and thus, snapped off of the bolts after excessive force. An example of this can be seen in Figure 5. Due to the hole becoming larger, the shovel guides had to be removed for the remainder of testing. Without the guides, the snow plow was not able to fully clear the snow in front of the wheels.

**Figure 5 - Moment of Failure of Shovel Guide**

The shield performed as intended. It blocked snow, blown from after being thrown, from hitting the user or their wheelchair's electronics. However, the lack of shielding elsewhere did allow snow to hit the user's legs. While not critical, it was a point of improvement related to the shield component.

A particular note is that snow built up on the snow plow during use. You can see examples of this in previous pictures, such as Figure 4 and Figure 5. The thrown snow was blown back onto the snow plow. Like other snow blowers, it is important to clear snow off of the device as maintenance. Leaving the snow risks the snow melting and refreezing as ice. The ice may very well lock up the power shovel, preventing rotation and damaging the motor if turned on. Ice could also lock up the power shovel's funnel and prevent rotation.

# 7. Conclusions and Recommendations for Future Work

This project and the development of this prototype taught us a lot. We discovered more about circuits, their electrical components, and how they function. As a consequence, we were able to connect the electricity of the snow plough to the wheelchair. We went deeper into the voltage and resistance readings since a multimeter was used to assess whether or not the connections were correct. We learned how to solder, drill, and weld, which was all new to us. Furthermore, because we had some expertise with Solid Works and CAD design, our skills in those areas improved alongside we learnt new things. We produce a wide range of CAD designs and accurate CAD drawings. Finally, we were able to 3D print using Solid Works.

We don't have many choices for assisting those with impairments. As a result, a desire to educate society in order to assist these people leads to a wider openness to disabled individuals. More individuals wishing to help those in need would lead to the development of more ideas and the creation of more operations that would benefit them. As a result, handicapped persons can undertake a variety of tasks and work just like everyone else. The easiest approach to achieve this is to put yourself in the shoes of the disabled person and attempt to imagine what he would require. It may be difficult for some people to accomplish this, therefore seeking the assistance of someone with a handicap may be beneficial. We will be able to get more individuals engaged on initiatives that will benefit those people and improve their lives.

Given more time, we would fix faulty parts of the design, including but not limited to: the shovel guides connection to the snow plow, the height of the clamps to allow the power shovel to have better contact with the ground, and the electrical box design. The shovel guides connection would be redesigned for a more rigid and stable connection. Washers would be added to prevent cracking of the shovel at the bolt connection. The height of the clamps was the main reason the power shovel did not have great contact with the ground. Lowering the upper clamps even lower may fix this issue. The electrical box could be improved in design. The standoffs would be made thicker to accommodate self-tapping screws, and leveraged inner walls would be added to the base

of the box while an equal wall or groove would be added to the lid to better prevent any water or snow from entering the box. These are just the improvements we could think of now. There is likely great deal of potential improvements that we have not thought about yet.

# APPENDICES

## 8. Design Files

This project's MakerRepo repository holds all of our design files for this project. The link to the repository can be found here.

**Table 5. Referenced Documents**

| Document Name | Document Location and/or URL | Issuance Date |
|---|---|---|
| 3D Printing File for Electrical Box: Lid | On this project's MakerRepo. Here. | Dec 5, 2021 |
| 3D Printing File for Electrical Box: Base | On this project's MakerRepo. Here. | Dec 5, 2021 |