Design Two
Adjustable Art Table

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Objective

What the Product Does

Basic Functions

This table will provide a smooth and steady surface for artists to work upon. Foremost, the table shall be safe so that nobody is injured haphazardly. Once this is assured, the table should be able to adjust in height so that it could fit somebody in a wheelchair comfortably underneath it. This means that its clearance must be higher than the legs of someone in a wheelchair, the width must be wider than the wheels on the wheelchair, and the depth must be longer than the legs of someone sitting in the chair. If the user is comfortably underneath the table, the table will be lowered so that the artist can be comfortable without feeling enclosed. While underneath the table, the user should have confidence that the table will not fall. Additionally, it shall not be so unstable that the quality of the artwork is compromised. When the artist feels inclined to leave the table, it would be easy to do so. The height adjustable art table could then be adjusted for the next user. The table shall be reliable enough to withstand many adjustments over many years without maintenance, other than cleaning the surface. A height adjustment would be useful for the artists at Passion Works to be more comfortable and create the art they enjoy.

Various accessories could be added to the table once it performs the basic functions. To prevent materials from rolling off the table, a lip on the edge of the tabletop could be added. It may be desired that the user know the height of the table when it is in a comfortable position. A height display could help the user adjust the table to the desired height on the first try. These amenities, although attractive and may increase user productivity, are unessential to the basic functions.

How It Will Be Implemented

The table will be developed by purchasing the basic components, assembling them and then testing them for safety. This will be done by essentially three main stages. Firstly, the tabletop will be purchased that has a size and finish that is appropriate for art purposes. The tabletop is an important piece in the table because it must have good durability since it will be used very often throughout the day. The laminate surface would also make for an easy clean up. Knowing the weight of the table will be important in adjusting the raising pressure for the two pneumatic cylinders. We want the pneumatics to rise slowly when the button is pressed. If the table should be lowered, then the user should be able to press the button and push gently on the table to lower it.

Most importantly, the device and its operations must be failsafe. The safety of the user is of utmost importance and will be forefront of concerns. The button and the moving cylinders pose a potential safety hazard and should be dealt with accordingly. One could assume that the button could be accidentally pressed. If this is the case, the table would raise and will not crush anyone underneath. The texture, corners and edges of the tabletop must be specifically designed. To reiterate, the height adjustment mechanism must not cause harm to the user while in operation
or while the table is being used. Ideally the project will improve upon the past and existing tables and also satisfy the needs of those at Passion Works Studio.

**Block Diagrams**

**Helper’s Perspective – Appendix I**

The diagram is a basic schematic that represents how the user will interact with the table. It is composed of a feedback loop that would allow the user to become most comfortable with the table. Once the user is comfortable, the remainder of the block diagram shows instructions on how to use the table.

**Design Process – Appendix II**

The schematic represents Team 9’s plan of execution to implement the manufacturing of the height adjustable art table. As of now, the team is currently on the Design Process step.

**Major Components**

The following diagrams of the front view and the side view of the tabletop show the dimensions of the table. As previously mentioned, the height, width and depth have to accommodate someone who may be in a wheelchair. Therefore, since the average wheelchair has a height of about 40” and a width of 26” then the table is designed so that there are an extra couple of inches for precautionary concerns. Using a top down approach, one should note that there are rounded corners of the tabletop. This will assure that nobody will hurt themselves when walking into the tabletop. The table will be supported by two adjustable legs on the sides of the table which will be mounted to a base. The base will be wide enough to provide support, and will extend all the way to the front and back of the table to prevent the table from tipping.
Side View

Figure 3: Side View

Figure 4: Side View
The side view depicts the depth of the table which could not be seen in the front view. The table was designed to have a depth of 30” which will give the artist enough room for moderately sized art project. At the rear of the table the button can be used to raise and lower the tabletop.

**Three Dimensional View**

![Three Dimensional View](image)

*Figure 5: Three Dimensional View*

**Subunits of Design**

**Tabletop**

In addition to the safety of the tabletop already mentioned, the tabletop itself should have dimensions that are optimal to those using it so that material is not wasted. The tabletop should be sturdy enough so that it can handle the required weight limitations. It could possibly be surface treated to prevent art markings, increase its aesthetic longevity and provide an easy way to clean it. The table should be smooth enough so that the texture of it does not appear when the artist is penciling on paper directly on top of the table, and also it should be large enough so that the user could do artwork on it.
The table that has been found is a laminate art table made by Space Table. The interior is a particle board that is compressed together which makes for a light weight yet strong table. The total weight of the top alone is 47 pounds, which will be given to the company that adjusts the gas cylinders for exerted pressure. The table top has a laminate surface finish that can be either made by Wilson Art or Formica which give it a smooth non-porous surface. Included in the price (in the budget) of the table top are rounded corners and edges, and also an optional T-Mold edge which provides for a soft edge. The soft edging and also the rounded corners would account for some safety concerns about people accidentally hitting the table. This strong, yet lightweight and safe material is an ideal table top however the price is somewhat expensive. In the future, if the budget for the optimal design becomes close to $750 then a cheaper table top with the same features could be found from another manufacturer, since the manufacturer of the mentioned table top is known to be expensive.

**Height Adjustment Mechanism**

The adjustment mechanisms for the table are two locking gas springs. The springs are placed opposite each other on each side of the table, and the adjustment control is located at the rear of the table. In a gas spring, a piston is fitted inside a cylinder with nitrogen gas under a specified pressure. When a valve is opened, the piston is moved either up or down based on the external forces exerted on it. Standard gas springs will only lock in a position in the fully extended configuration, or if the external force is large enough in the fully retracted configuration. On the other hand, locking gas springs allow the spring to be adjusted to any length and locked in place. This is because a release lever is inserted in the cylinder; only when a control button is pushed does the release lever move to allow the piston to travel.

Both types of gas spring work based on the same physical principles. The force exerted by the gas through the piston rod is based on the surface area of the piston and the pressure of the gas.

\[
Area = \frac{\pi \times \text{diameter}}{4}
\]

\[
Force = area \times pressure
\]
In order to raise the table, the force exerted by the gas must be larger than the external forces of the table surface and any objects resting on the table. To lower the table, there must be sufficient forces applied to the top of the table to overcome the force exerted by the compressed gas. It is desirable to compress the nitrogen to a pressure that will exert a force slightly larger than the weight of the table. This will cause the table to slowly rise, and minimal force would be required from the user to lower the table. As stated earlier, the tabletop and mountings are going to weigh approximately 50 pounds, so each gas spring needs to be pressurized to provide a force a little larger than 25 pounds.

There are two main types of locking gas springs, elastic blocking and rigid blocking. Elastic blocking springs are filled only with nitrogen gas, and when locked will give a bit when external forces are applied. This creates a bounce effect on the spring such as in computer chairs, where a person is cushioned as they sit down. The rigid blocking springs resist all movement once locked, which is achieved by including a compartment of oil in the cylinder in addition to the nitrogen gas. The oil is not as easily compressed as the nitrogen gas, so when the external forces are applied the spring remains securely in place.

The locking gas spring used for the table is a rigid blocking gas spring from Easylift. The spring is rigid blocking in the push-in direction, meaning that it will resist moving under larger compressive forces. The configuration of the locking gas spring is important in determining the blocking type of the gas spring. In the rigid blocking in the push-in direction the oil is located between the piston and the end of the cylinder, and the nitrogen gas is located behind the piston and a floating piston. The floating piston separates the gas from the oil without making a rigid boundary. The piston is able to adjust as normal when unlocked, but when locked the oil is uncompressed, and there will be no movement. In rigid blocking in the pull-out direction, the floating piston is between the piston and the end of the cylinder and the gas is between the floating piston and the end of the cylinder. The oil is located between the floating piston and the piston, blocking the piston from being pulled out in the locked configuration. The configuration of the rigid blocking in compression gas spring is depicted in figure 7. For these locking gas springs the material of the piston, rod, and cylinder are steel, with zinc plated steel connecters. The oil is hydraulic oil and the release levers are made out of stainless steel.
The locking gas springs used for the table have specific dimensions and force requirements to operate the table. The specifications for the spring are presented in Table 1.

![Rigid Blocking in Compression Gas Spring](image)

**Figure 7: Rigid Blocking in Compression Gas Spring**

<table>
<thead>
<tr>
<th>Stroke Length</th>
<th>Diameters of Rod/Piston</th>
<th>Force of Gas</th>
<th>Length of Gas Spring (Fully Extended)</th>
<th>Blocking Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 mm (13.78 in)</td>
<td>10/22 mm (.4/.87 in)</td>
<td>115 N (25.8 lbs)</td>
<td>927 mm (36.5 in)</td>
<td>12000 N (~2,700 lbs)</td>
</tr>
</tbody>
</table>

The stroke length of the gas spring is the distance the spring can travel. The project specifications require that the table be able to travel between 27” and at least 40” off the floor, so the required stroke length is only 13”. The stroke length of this gas spring allows for a little under an inch more travel, providing a larger range of adjustment than required. The gas spring is set to provide a force of 115 N, which is equal to 25.8 pounds. This is enough to cause the table to slowly rise once the locking mechanism is released. When the release lever is locked into place the table will resist moving under applied forces, and maintain a stable surface for the
user to complete art projects on. The blocking force of the locking gas spring corresponds to the amount of force that the gas spring can hold while locked without failing. This gas spring can withstand approximately 2,700 pounds, so the table itself can withstand approximately 5,400 pounds. This permits the user to store heavy objects on the table when not in use, and also ensures that the table legs will not fail if a heavy person sits on the tabletop.

In order to adjust the table the locking mechanism must first be disabled. The mechanism is controlled by a parallel hydraulic release system, which uses water to connect the control system to the springs. The hydraulic release system is the best system for operating the locking mechanism of the gas springs because of the ease of use. In other operating systems the mechanism is based around a lever or a handle requiring the user to exert force to operate it. The hydraulic release is based on a single button, which requires very little force from the user and is easily manipulated while adjusting the table. The table requires two gas springs as supports, so adjusting both at the same time would be difficult with other release systems. The hydraulic release system is the only system that can be configured into a parallel release. The parallel hydraulic release system allows for the integration of the controls for each gas spring into one control. The controls for both gas springs would be controlled by a single button, allowing one person to raise both with one hand. This also ensures that both gas springs are operated at the same time, taking away the risks of unequal adjustments and an uneven surface. Since hydraulic release systems are attached to the gas springs with hoses, the control can be attached to any location on the table. The release systems based on levers have limited range, and wouldn’t be able to be put in the most optimal location. The parallel release system is depicted in the following figure.

![Parallel Hydraulic Release System](image)

The release is going to be located on one of the longer edges of the table, where the user can apply even pressure to the table so that both sides are adjusted equally. This also allows for the user to choose whether they want to sit with the control at their lap, or at the back of the table. For a person controlling the table by themselves, it would be best to sit on the side of the table with the control. This would allow the user to adjust the table to the optimal height without
needing to get up. For a disabled person requiring someone else to adjust the table for them, it would be best to sit opposite of the control. This would allow the person to sit under, or wheel under in a wheelchair, and someone else could lower the table down to their optimal level.

If one of the gas springs should fail, the blocking strength of the second spring is so large that it will be able to hold the table steady on its own. This is an important safety feature because it prevents the table from collapsing on the artist underneath. Also, it would keep the table at an even level for the artist by not allowing the other leg to creep either up or down if the locking mechanism of one of the legs is faulty. The gas springs will be able to work under all conditions that will be experienced at either Passion Works or an art studio. The allowed temperature range is from \(-30^\circ C\) to \(80^\circ C\), or \(-22^\circ F\) to \(176^\circ F\), which should contain all possible temperatures that could occur in the studio.

The safety of the users and bystanders is of utmost importance when dealing with a device such as this. The table is designed so that when it is locked in place, the pneumatics will stay in the same exact position as long as the button is not pressed. So that the button is not pushed accidentally, it will have a safety cover that must be opened so that the button is accessible. If the safety latch remains closed, then the button cannot be accessed and therefore the pneumatics will not be moved.

**Table base**

The core of stability of many tables in general is the design of the base, and what material the base is made out of. In this case, the table’s base is going to consist of two 2X4 blocks of Douglas fir wood which will extend directly under the right and left sides of tabletop. Douglas fir wood is very durable and relatively easy to manipulate. This type of wood is used in many applications around the United States including housing construction as well as for flooring purposes. The great strength of this wood will provide extra stability while holding up against the forces that the gas springs may exert on it. This wood is also versatile in that it can be fabricated to comply with many different uses for it. This will come into play when the gas springs are mounted to the wooden base. Also, when comparing the cost with other types of wood, Douglas fir is one of the cheapest. This is because this wood comes from very productive Douglas fir timberlands located in the northwestern part of the United States. Overall, this wood will give this art table the most efficiency at the lowest cost.

**Portability**

When constructed, this adjustable art table is going to sit in the middle of the art room for all artists to use and enjoy. This art table is also not specifically specified to be mobile by our client, but we were given the option to make it mobile. By this table not being mobile, the versatility of it is greatly diminished. In order to efficiently make this table mobile, factors of impinging on the stability of the table must be taken into account. Even though the table is going to be used mainly in the center of the art room, there will be a few times when it will have to be moved around. These instances may occur if the furniture in the room is being rearranged or if the room has to undergo certain types of cleaning or maintenance. The device which will give the mobility is that of a wheel. This is a simple and easy method for making the table portable. How the wheels are arranged in the assembly of the table will greatly determine its stability. It would be logical to mount four wheels underneath the base of the table. Two wheels on the right
side and two wheels on the left side. These four wheels would also come with a locking mechanism on them. Once the table is in a desired place, the lock clip would just be pushed down on each wheel with minimal effort which would lock them in place. This would secure the table in all directions from it being moved by an artist in the room. This method is foolproof, except for one minor detail. Another issue with this table that has been stated by our client was that it must be very stable. If the wheels are mounted underneath the table, it compromises the stability of the table and makes it possible for the table to tip. If an artist using the art table was unaware of this, a safety hazard situation may be created for him or her. To make this safety and stability issues negligible, the wheels would not be mounted below the base. Only two wheels would be used, and these wheels would simply be mounted to the rear of the base. This setup can be seen in the figure below.

![Figure 9: Wheel Attachment](image)

Now, the table could simply be moved by lifting the front of the tabletop which will tilt the base as to have the two wheels on the back of it make contact with the ground. The lifting of the tabletop should require minimal effort since our table will be made out of light and durable materials. With the wheels at the back of the base, the table will be portable on demand as well as have maximal stability with the base still flush with the ground.

**Accessories**

Accessories for this art table will maximize the luxury for the Passion Works artists using it as well as for anyone who wishes to use it. This will also help in the marketability of the art table. An accessory which will be implemented in this design will be that of a height sensor. This height sensor will allow the user to know the height of the tabletop by the press of a button. This will save a lot time for future height adjustments for a particular artist since it could be noted exactly what height they had the table adjusted to for their previous usage of the table. This height sensor is made by Zircon. It uses ultrasonic waves which are emitted from the device and
then bounced back from the object it is measuring the distance from. A photo of the actual product can be seen below:

![Zircon Sonic Measure](image)

**Figure 10: Zircon Sonic Measure**

This height sensor has a range from 2 to 44 ft. It is 99.55% accurate when measuring to the nearest inch. The height of the table will be adjusted in units of inches and the height sensor will cover the whole range of height adjustments the of the art table. This device is very beneficial, as well as safe, for all the Passion Works artists who will be using it. The weight of this device is only 2.5 ounces. This makes the weight of this measuring tool negligible of adding any amounts of weight which could create extra moments about the pneumatic height adjusting mechanisms no matter where it is placed under the tabletop. This device does have a switch, but even if another artist in the room came by and hit a few buttons, it would merely change the units or dimensions the height sensor is reading. It could easily be readjusted to measure in the correct units. Touching any button on this device will not at all have any affect on the tabletop’s orientation in space. This height reading device provides little potential hazard for artists using the table, as well as knowledge about comfortable height levels of the tabletop for the artist.

When this device is purchased, it cannot simply be mounted to the bottom of the tabletop. This is because the wave generator sits above the display screen. This device will have to be taken apart and rearranged into a readable upright display just under the tabletop. All of the components in the height sensing device will be secured into a wooden frame. This will ensure that the components stay where they are at all times while the table is in use. The height sensor will be oriented toward the ground as it will be reading constant heights accurately from here when needed to do so. All that is required to power this device is a 9V battery. This will power the device by being placed in the back of the wooden box which encloses the whole height display system. This will reduce any risk of someone coming along and having easy access to take the battery out of its place in the box. By the height device being battery powered, it requires no use of a power cord which would have to extend across the room in order to power it. When the height sensor is taken apart and reconfigured, the ultrasonic wave generator will be oriented toward the ground while the actual height display screen will be oriented just below the tabletop for the artist to easily see. It will also not protrude out from the tabletop as it could
impinge upon by an artist sliding into a drawing position along the edge of the tabletop. A schematic of this can be viewed below.

As the client desires, certain accessories can be added to the table afterwards. This includes holders for pens, pencils, paintbrushes, chalk or beverages in possibly separate compartments. If the user wishes, there could be a lip on all edges of the table so that materials do not roll or liquids do not drip off the table.

Figure 11: Height Display Attachment
## Budget

*Table 2: Budget*

<table>
<thead>
<tr>
<th>Part</th>
<th>Manufacturer</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locking Gas Spring</td>
<td>EasyLift Springs</td>
<td>2</td>
<td>$96.40</td>
</tr>
<tr>
<td>5.2 Parallel Hydraulic Release</td>
<td>EasyLift Springs</td>
<td>1</td>
<td>$93.00</td>
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<tr>
<td>30’ by 42’ Space Table w/ T-Mold Edges</td>
<td>WilsonArt</td>
<td>1</td>
<td>$214</td>
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<tr>
<td>Height Display</td>
<td>Zircon Sonic Measure</td>
<td>1</td>
<td>$32.80</td>
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<td>Wheels</td>
<td>Home Depot</td>
<td>2</td>
<td>$4.97</td>
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<td>10’ of 2’ by 4’ Douglas Fir</td>
<td>Lowe’s</td>
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<td>$3.71</td>
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<tr>
<td>Miscellaneous Screws, Bolts, etc</td>
<td>To Be Determined</td>
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<td>$30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$576.25</td>
</tr>
</tbody>
</table>
Appendix I: Block Diagram for User

Helper's Perspective

Is Height of Table High Enough for User to Fit Underneath Comfortably?

NO
Press and Hold Release Button
Apply Pressure to Slowly Lift the Table to Appropriate Height
Let Go of Release Button

YES
User Positions Themselves Under the Table
Press and Hold Release Button
Apply Force to Top of Table to Gently Lower Table to User's Desired Height
Let Go of Release Button
Start Art Project