Design of Table with Adjustable Height

by

Nurul Masnem Ahza Bt Rusli

Dissertation submitted in partial fulfillment of

the requirements for the

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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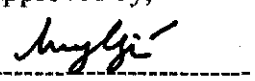
Approved by,



(Ms. How Meng Git)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NURUL MASNEM AHZA BT RUSLI

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ABSTRACT

The design of a table that can offer larger amount of flexibility seems more attractive for multitasking and in meeting wider range of the user requirements and needs on personal level. Table with adjustable height has been developed in order to meet these necessities. Different people require different table height to ensure they are comfort while using the table for their intended purpose. With respect to a single individual needs, his/her measure of comfort while using the table does varies over time and the type of activity or task performed. The survey on 80 students of a local university in Malaysia that resides in the same hostel block and utilize the same type of workstation showing that there were about the same in the number of students who fit and who do not fit with the current condition of the study table provided, in terms of the leg room available and the elevation of the table top off the floor. The outcome of the survey becomes the base of the design objective, that is to improve the current workstation by proposing a new design of a workstation that consists of a book shelf and a table top that can be adjusted in terms of its elevation off the floor to provide the necessary amount of leg room with respect to an individual requirement. The design of the table is based on the established ergonomic guideline in table design and taken into account the proposed suggestions by the survey responders. The engineering design analysis was carried out to determine the right configuration of the table top and the book shelf that will remains stable upon load application by considering the worst case scenario, that is the application of the load at the extreme edge of the table top when the table is at its minimum height. The outcome of the project is a workstation that consists of an adjustable table top that is attached to a 2-tier book shelf. The adjustability of the table top is in terms of its elevation off the floor and its tilt angle. The height adjustment is achieved by means of bar linkages, where the sliding motion of a link with respect to the movement of another link resulting in height adjustment in the range of 60 cm to 80 cm off the floor, while the tilt of the table top is achieved by locking and unlocking the joint between a support rod and one of the link. The table top can be tilted from complete horizontal to complete vertical.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The basic and common configuration of a table is having a flat horizontal top that is raised to some height vertically by either a set of legs, pillars or trestles [1]. The top may be made of stone, metal, wood, or a synthetic material such as plastic. Tables may be subdivided based on many characteristics such as the shape, material used, height, type of support structure, number of support structure used, purpose for which they are constructed, addition of compartments, mobility and many other characteristics, but the most basic and significant characteristic used to subdivide the tables is in terms of flexibility, classified as fixed or mechanical. A fixed table is the table whose top and support structure can't be moved in any way to expand or reduce in size for storage purpose. The top of fixed table can be quite sizeable and may be supported by a single column or pedestal. A mechanical table is a vice versa of fixed table, where either its top or support structure or both can be reconfigured to reduce its size for storage purpose or to save space or to fit the user's requirements based on the activity the user do when using the table. The mechanism of configuration could be folding, tilting and height adjusting.

The function of a table varies according to the requirements and the activity intended by the user [1]. Tables found in cafeteria generally functioned as a stand where meals are served to enhance the comfortability of the users while having their meals. As compared to the tables in offices, schools, libraries and laboratories, they functioned as a workstation, where the users perform their intended activities on the table such as writing, drawing, reading, typing, and experimenting. When the table is used to serve personal purpose, the users will tend to make selection based on their personal needs. For example, a university student whose workstation consists of a laptop, a printer, a book shelf and a stationeries holder would require a table that can house all of his/her workstation equipments and keeping everything within reach. In

this matter, the size, the shape and the robustness of the table are of main concerns in making selection. Another important aspect of consideration is the height of the table. It determines the amount of leg room available and the distance between the student and the table top. It is of main concern that the table has enough leg room that the student can seat comfortably closed to the table with his/her feet rest flat on the floor and the upper side of the thigh did not touch the bottom part of the table top, while at the same time providing a comfortable distance between the student and the table top where the student can at least placed his/her hand flat on the table without hunching the shoulder or slouching the back.

The background of study for this project is a hostel block in one of a local university in Malaysia, focusing on the condition of the study table provided in the hostel room for the students. All of the hostel rooms in this block are equipped with similar type of furniture with similar arrangement. Each room is of 300 cm x 325 cm sectional area and with a height of 350 cm. Each is equipped with a sleeping bed, a study table, a closet and a hanging book shelf. Figure 1 shows the arrangement of these items inside the room and Table 1 shows the dimension of each item.

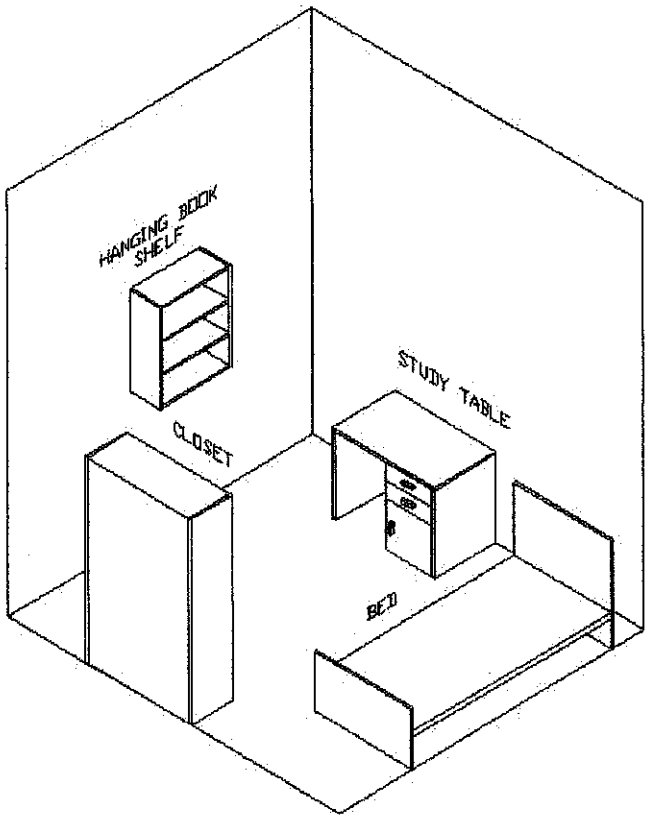


Figure 1: Arrangement of the items inside the room

Table 1: Dimension of the items inside the room

	Item	Elements	Quantity	Dimension (cm)
1	Study table	Table top	1	60 x 100 x 2
		Leg room		60 x 49 x 73
2	Hanging book shelf		1	30 x 70 x 83
3	Bed		1	199 x 95 x 90
4	Closet		1	40 x 104 x 170

1.2 Problem Statement

1.2.1 Problem Identification

In order to identify if there is a problem with the current workstation provided in the hostel, a survey was done on a group of 80 students who reside in this block. The questions asked were to determine if there is a sufficient leg room with respect to the design of the table, and if the student is comfortable with the table's height. The survey is also asking for the students' opinion on how to improve the current condition of the workstation. The detailed analysis of the survey is presented in section 4.1. Figure 2 shows the responses of the students to the first two questions asked.

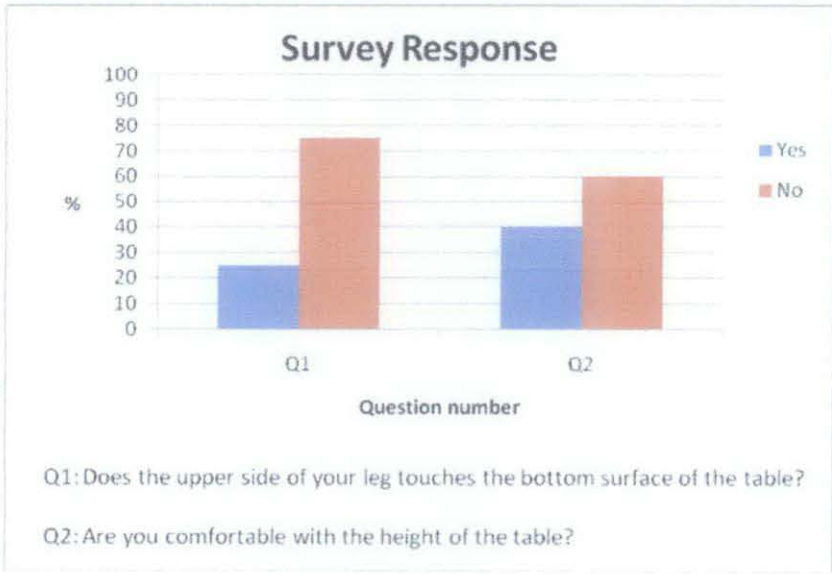


Figure 2: Survey respond on the condition of the current study table used

It can be seen in Figure 2 that 60% of the students are not comfortable with the table's height, and 25% of them are the one whose upper side of their legs touches the bottom surface of the table while sitting, indicates that the leg room is not sufficient for the respective students. Based on this number, it can be deduced that to some group of students, they are not comfortable with the current condition of the study table provided in terms of the leg room available and the elevation of the table top off the floor.

1.2.2 Significance of the Project

The project aims to improve the current workstation provided in the hostel room of the selected sample of focus, by proposing a design of a workstation that is based on the established ergonomic guideline in workstation design as well as the suggestions provided by the subjects of the survey, to increase the level of comfort of the students when working within the workstation.

1.3 Objective and Scope of Study

1.3.1 Objective

To design a workstation that consists of a book compartment and a table top that can be adjusted in terms of its elevation off the floor to provide the necessary amount of leg room with respect to an individual requirement.

1.3.2 Scope of Study

1. Survey on 80 students of a local university in Malaysia to identify the area of improvement of the current workstation provided in the hostel.
2. Design a workstation that consists of a book compartment and a table top based on the ergonomic guideline in workstation design and the suggestions by the survey responders.
3. Evaluation of the stability of the design through engineering analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Common Features and Applications of Table with Adjustable Height

Table with adjustable height is capable to suit the specific physical needs of its user in order to maintain optimum ergonomic positioning [2]. It may also be custom made to accommodate specific needs of the individual with disability. Additional features of the table with adjustable height may include:

- wheelchair cut-outs
- cable holes
- cable trays
- adjustable angled tops
- locking castors
- keyboard platform
- built-in monitor raiser
- telephone shelf
- adjustable feet
- printer shelf
- a range of storage options
- preset memory options for preferred positioning of table

The height adjustable controls may be manual, electric, pneumatic or hydraulic and may be operated using a hand, knee or foot control, computer or remote control, lever, or button. Some models of this table have memory settings that allow the users to preset adjustments to suit their individual needs and is operated by push button controls.

Table with adjustable height may be constructed from a variety of materials. The table top may be constructed from laminate, wood, wood covered with a non-

reflective melamine finish or steel. Table legs may be constructed from steel or powder coated metal.

Table with adjustable height is generally used within an office environment. A large range of shapes and sizes are available to fit within the space requirements of individual workplaces.

2.2 Ergonomic Guideline in Table Design

The features of a table based on the guideline stated in American National Standards Institute and the Environmental Health and Safety Center are as follow [3]:

2.2.1 Leg room

The table should allow sufficient leg and knee space so that the user can come as close as possible to the work area top. The leg room should be at least 30 inches wide by 19 inches deep by 27 inches high. Drawers and table legs should not go where human legs need to fit.

2.2.2 Work Area Top

Rounded corners are recommended so that arms and wrists do not come in contact with any sharp or square edges. The work area top should be big enough to allow space for the basic necessary equipments needed while performing work e.g. paperwork, books, and stationeries. Frequently used items should be kept close and within reach. A general recommendation is that the work area top should be at least as big as the standard office desk; 30 inches by 60 inches. The recommended thickness of work surface is 1 inch.

Table 2 summarizes the details of the guideline.

Table 2: Ergonomic guideline in table design

Features	Characteristics	Indicator
Leg room	Width	30 inches (76 cm)
	Depth	19 inches (48 cm)
	Height	27 inches (68 cm)
Work area top	Width	30 inches (76 cm)
	Depth	60 inches (152 cm)
	Thickness	1 inch (3 cm)
	Edge	Rounded corners

2.3 Existing Products in the Market

Some of the existing products in the market are shown in Table 3. They were tabulated in terms of height adjustable mechanism, height range, table top and frame material, the dimension of the table top and other features available.

Table 3: Existing products in the market

Product/Model	Manufacturer/ Dealer	Height Adjustable Mechanism	Height range	Table top and frame material	Table top dimension	Features
Adjustable height tables with hand crank mechanism [4] 	Ergo in Demand	Crank	19.5"to 29.5"	Vacuum formed mahogany and powder coated steel frame	Width: 43" Depth: 29.5"	•Equipped with adjustable leveling glides for placement of CPU or paper tray •Work surface is designed with a "cut-out" that enables users to get closer to the work surface if required
Pneumatic Sit-Stand Workstation [5] 	Uptime Business Products	Pneumatic	24.75" to 32.5"	Teak vacuum formed platforms and steel frame	Width: 20" Depth: 15"	•Equipped with caster wheels for ease of mobility •Adjustable CPU holder •Keyboard slides
ABCO Adjustable Height Folding Table [6] 	Flaghouse	Screw	24" to 30"	High-pressure laminate and black powder coated base	Width: 30" Depth: 60"	Foldable

CHAPTER 3

METHODOLOGY

3.1 FYP Flowchart

Figure 3 shows the approach taken to fulfill the objective of the project.

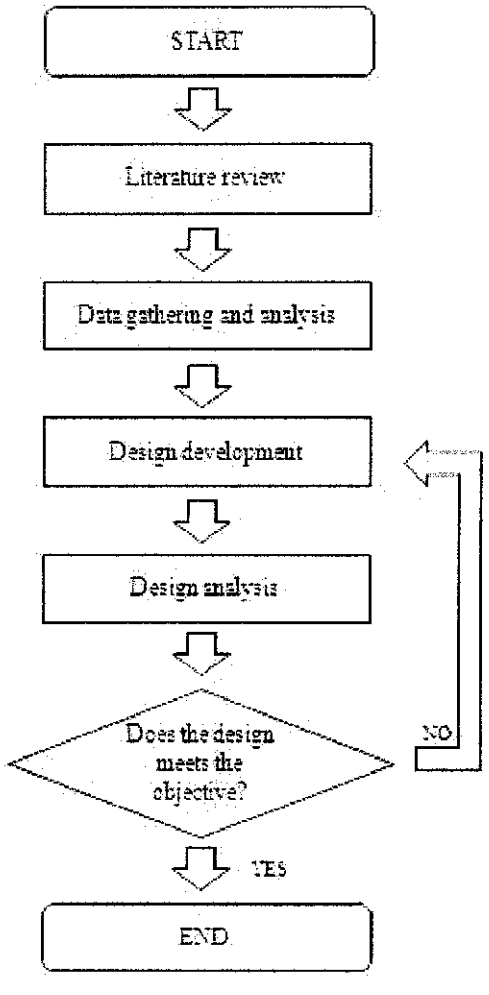


Figure 3: FYP flowchart

3.1.1 Literature Review

The existing products in the market that utilizes the concept of height adjustable were reviewed and analyzed in terms of the height adjustable mechanism, the height range of the table top and the material used for the table top and frame. The ergonomic guideline in table design was reviewed and taken as the reference in designing.

3.1.2 Data Gathering and Analysis

A survey on 80 students of a local university in Malaysia was conducted to examine the condition of the current study table provided in their hostel room. The questions asked were to determine if there is a sufficient leg room with respect to the design of the table, and if the student is comfortable with the table's height. The survey was also asking the students' opinion on how to improve the current condition of the study table.

3.1.3 Design Development

Starting by defining the goals and constraints of the design, some conceptual designs were generated and the design that meets most of the specified goals and constraints was selected. The material selection was done by comparing the alternative available materials in terms of their characteristics. The engineering design specifications were then developed and the engineering drawing of the design was generated based on the design analysis.

3.1.4 Design Analysis

The state of stress caused by the maximum load application onto the table top is been determined to make sure that the structure of the design won't fail upon load application. The distance between the load application at the extreme edge of the table top to the anchoring point of the book shelf was been determined to make sure that the structure retains its stability upon load application.

3.2 FYP Gantt Chart

The flow of FYP 2 is presented in FYP Gantt Chart shown in Appendix 2.

3.3 Tool

AutoCAD 2006 software is used in generating the engineering drawing of the design.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Survey Analysis

The outcome of the survey is as shown by Table 4. The survey questionnaire is shown in Appendix 1.

Table 4: Survey outcome

Question	Responses	Percentage (%)
When you are in the shown sitting position, does the upper side of your leg touches the bottom surface of the table?	Yes	25
	No	75
Are you comfortable with the height of the chair?	Yes	40
	No	60
If no, is the table too high or too short for you?	High	25
	Short	35
Is the table top area capable of accommodating all your necessary equipments?	Yes	38
	No	62
If no, is your work station equipped with a side compartment to house all your necessary equipments?	Yes	62
	No	0

The purpose of the survey is to determine if there were any aspects in the current table design provided in the hostel room that can be improved in order to increase the comfort level of the students. The aspects of concern were the available leg room, the height to where the table top is raised off the floor as well as the availability of space in the workstation that can accommodate all of the students' necessary equipments. The outcome of the survey, as shown by Table 4 indicates that these aspects were significant to be improved in order to suit more students that stayed in the hostel. Among the suggestions provided by the students on how to improve the current condition of the workstation were to increase the space to keep all of their necessary equipments when working in the workstation by either increasing the table top area or by providing a side compartment that is kept within the reach of the user, and to increase the size of the leg room so that the student can freely moved his/her leg without bumping into the table structure located under the table top. Based on the suggestions, the design goals and constraints were then developed.

4.2 Design Goals and Constraints

The design goals and constraints were developed based on the outcome of the survey. The main goals are to increase the leg room of the study table and the height adjustability of the table top off the floor. Besides of height adjustability, it was decided for the table top to be easily adjusted in its tilting angle, to serve a certain group of user who would prefer to work with the table top tilt at some angle when performing the intended activity. It was decided to increase the available space to accommodate the necessary equipments by providing a book shelf that is kept within the reach of the user. Below are the requirements that must be obeyed in designing the workstation.

1. The table must be able to withstand at least the weight of a laptop (approximately 5 kg).

2. The area of the table top should at least allow placement of a laptop and a feasible writing area. The feasible writing area defined by American National Standards Institute and Environmental Health and Safety Centre is 12 inches by 24 inches [3].

3. The mechanism used for the height adjustment must be easily operated by a single person.

4. The side compartment where the necessary items (e.g. books, stationeries, printer, etc.) are located must be within the reachable distance of the user with the condition that it is not in the way of the leg room.

4.3 Concept Generation and Material Selection

4.3.1 Concept Generation

Based on the design goals and constraints, three conceptual designs were generated and the design that satisfied the requirements the most was selected. The evolution of the design selection is summarized in Table 5.

Table 5: Conceptual designs

Design	A	B	C
Concept	An inclined table top supported by 4 legs mounted on an I-shaped bar that's attached to a pulley system as height adjustment mechanism	2 bar linkage that holds a table top at one edge, mounted on a base that stationed a side compartment. The height adjustment is achieved by means of locking and unlocking the joints of the supporting links	A table top that's attached to a book shelf that acts as the counterweight. The height adjustment is achieved by means of sliding motion of two links
Pros	The table top is equipped with storages for the compartment of the necessary items, and the storages are within the reachable distance of the user	Simple height adjustment mechanism	The book shelf is within the reachable distance of the user, measured from the edge of the table top. Simple height adjustment mechanism. The table top can be rotated from complete horizontal to complete vertical
Cons	The force needed to lift the table top is predicted to be large since the weight lifted would be the weight of the table top and the equipments placed on top of it	The weight of the table top is causing the whole structure to tumble since there is no appropriate counter weight applied. The table top itself is unstable since the joint force between the links are not sufficient to keep it stable	The stability of the table top upon load application is unknown but can be determined based on static analysis
Status	Decline	Decline	Accept

4.3.2 Material Selection

Two materials were being considered for the fabrication of the prototype of the design. These materials were being evaluated in terms of their characteristics. Each desirable characteristic was marked with a positive sign (+) and each undesirable characteristic was marked with a negative (-) sign. The material with more positive signs was selected. As shown by Table 6, wood was selected as the material for the fabrication of the prototype of this design.

Table 6: Material selection

Material	Characteristics	Indicator
Plastic	Lightweight	+
	Require high cost preprocessing to obtain the needed shape and dimension	-
	High fabrication cost	-
Wood	Available in multiple shapes and dimensions and can be obtained at scrap area	+
	Low cost preprocessing to obtain the needed shape and dimension	+
	Low fabrication cost	+
	Heavier than plastic but of considerable weight	+

Indicator: desirable characteristics (+), undesirable characteristics (-)

4.4 Engineering Design Specification

The suggested design for this project is a workstation with a table top that is attached to a 2-tiers book shelf with a locker. The table top is supported by two links that slide with respect to each other resulting in the changes of the table top elevation off the floor. The minimum and the maximum permissible height of the table top measured from the floor is 60 and 80 cm respectively. The table top is also rotatable from complete horizontal to complete vertical. The stability of the design was determined by the distance from the point of load application at the extreme edge of the table top to the anchoring point of the book shelf. The analysis is shown in section 4.6.

4.5 Bill of Materials

Table 7 presents the Bill of Materials for this design. The position of all sub assemblies is shown in Figure 4 and Figure 5.

Table 7: Bill of materials

		Quantity	Units	Material	Dimension (mm)
Sub Assy 1	Book shelf				
1-1	Vertical panel	2	pcs	Plywood	300 x 1380 x 15
1-2	Vertical panel	1	pcs	Plywood	700 x 650 x 20
1-3	Door	2	pcs	Plywood	335 x 600 x 20
1-4	Horizontal panel	2	pcs	Plywood	300 x 670 x 15
1-5	Horizontal panel	2	pcs	Plywood	300 x 670 x 50
1-6	Screw	24	pcs	Steel	M5 x 0.8
1-7	Nut	4	pcs	Steel	10 x 10 x 3, dia =5
Sub Assy 2	Table top				
2-1	Link 1	1	pcs	Wood	45 x 650 x 20
2-2	Link 2	1	pcs	Wood	45 x 650 x 20
2-3	Support rod	2	pcs	Wood	dia = 80, length = 700
2-4	Bracket	2	pcs	Steel	100 x 400 x 10, dia = 82
2-5	Table top	1	pcs	Plywood	500 x 700 x 20
2-6	Tightening nut	4	pcs	Plastic	dia = 80
2-7	Screw	8	pcs	Steel	M5 x 0.8
2-8	Bolt	4	pcs	Steel	M12 x 1.75

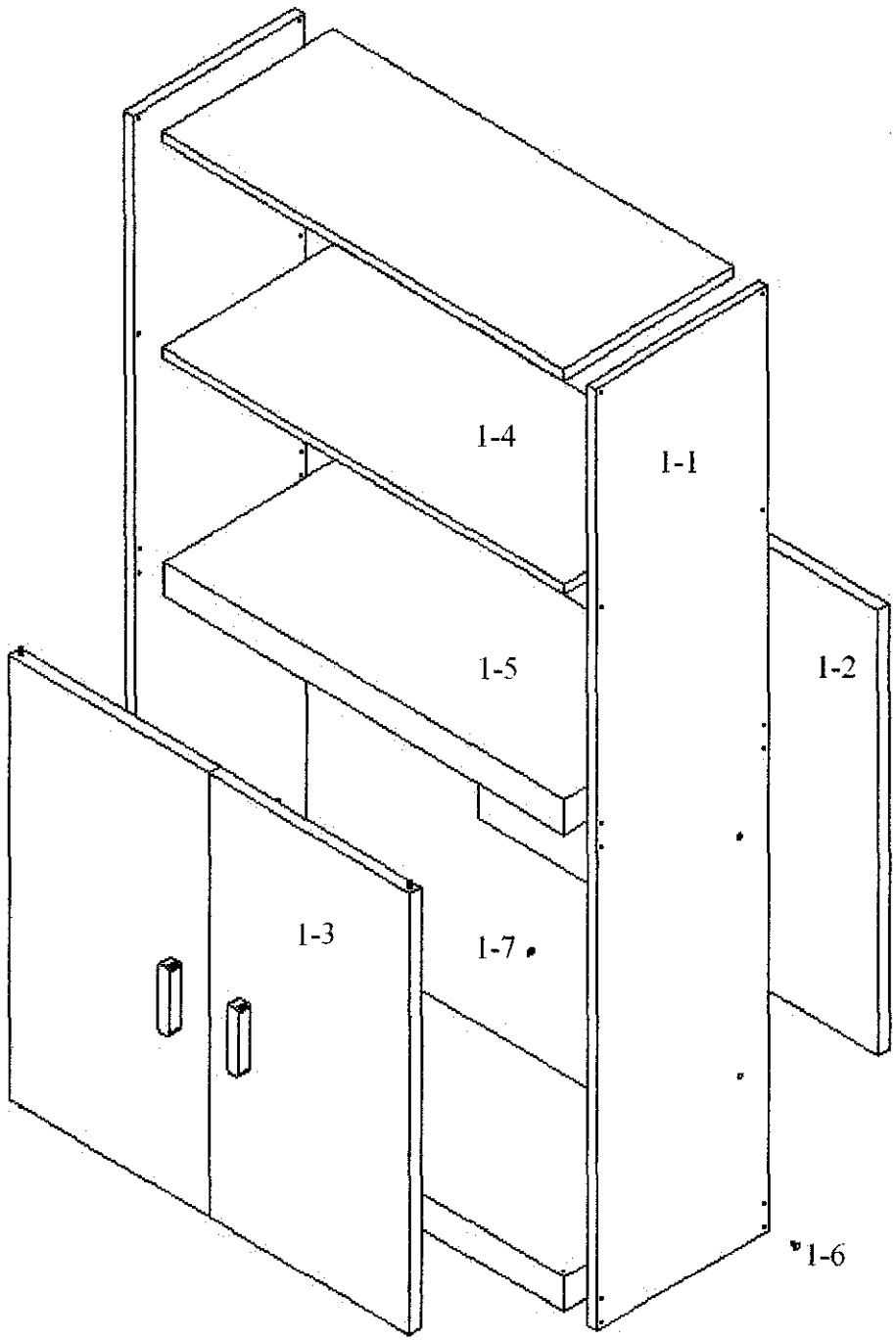


Figure 4: Sub assembly 1

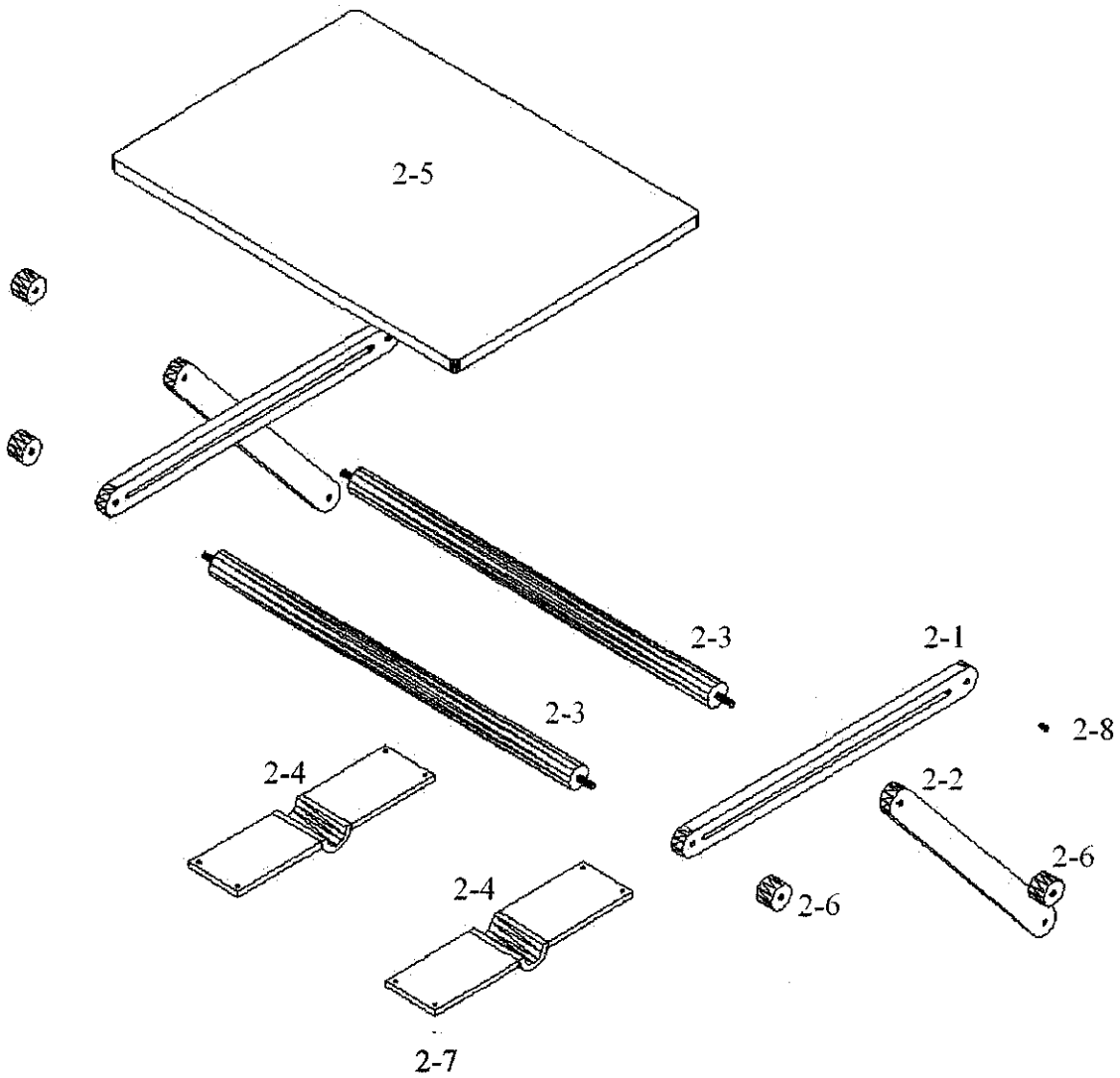


Figure 5: Sub assembly 2

4.6 Engineering Design Analysis

4.6.1 Analysis of Normal Stress Distribution on the Table Top

This analysis is to determine the amount of stress applied onto the table top upon the application of the maximum allowable load. The maximum allowable load that can be applied onto the table top as mentioned under the design goals and constraints is 5 kg. Figure 6 shows the isometric view of the table top. Each corner of the table top is labeled as A, B, C and D as shown. For this analysis, the load of 5 kg (50 N) is placed at point C to consider the worst case scenario of load application.

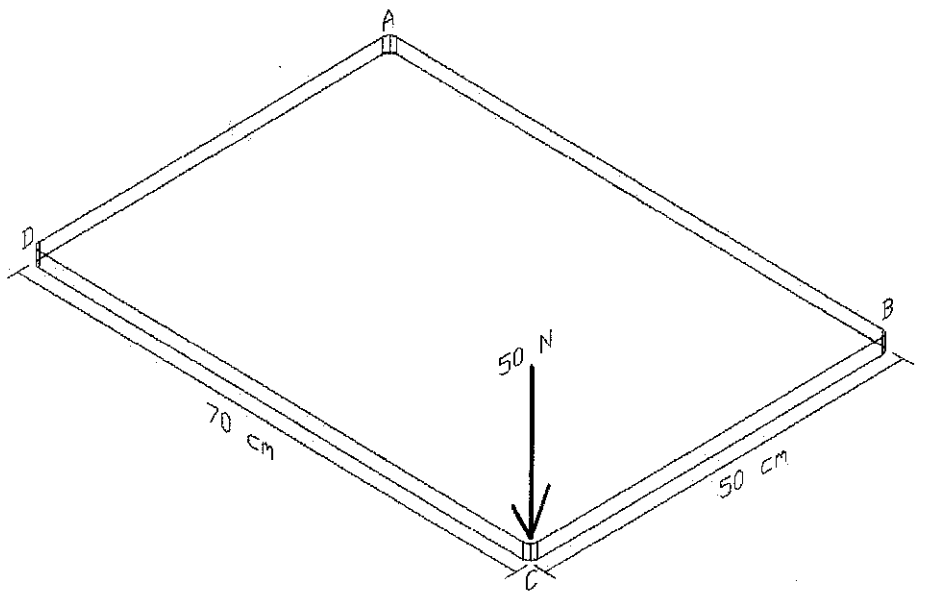


Figure 6: Isometric view of the table top with 50 N load acts at point C

In order for the table top to remain stable upon load application, the 50 N load must acts through the centroid of the table top's cross section resulting in two bending moment components that act about the principal axes of inertia of the table top. The bending moment created by the 50 N load about x and y axes were been determined based on the moment formula. Figure 7 shows the direction of the applied load acting through the centroid and the resulting bending moments.

Below is the calculation to determine the amount of the bending moments created by the 50 N load about x and y axes with respect to the origin.

$$M = F \times d \qquad [7]$$

M = bending moment

F = amount of load applied

d = distance of the load application from the origin

Moment about x-axis:

$$M_x = (50\ N)(35\ cm) = 17.5\ Nm$$

Moment about y-axis:

$$M_y = (50\ N)(25\ cm) = 12.5\ Nm$$

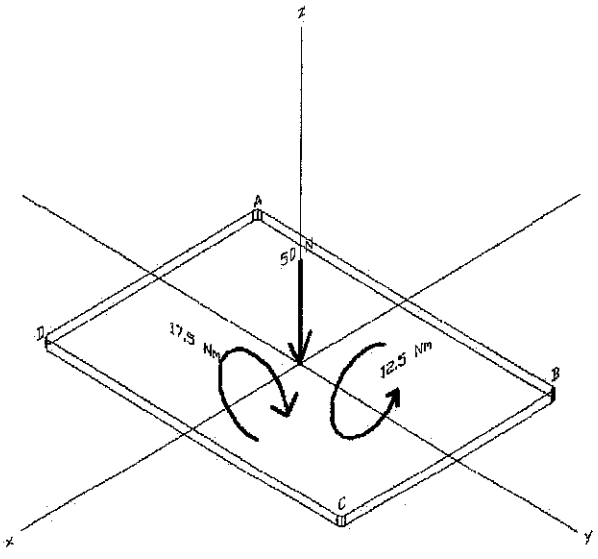


Figure 7: Direction of the applied load and the resulting bending moments

The following calculation is to determine the normal stress at each point A, B, C, and D upon load application of 50 N at point A.

The normal force acting on the table top is

$$\sigma = \frac{P}{A} = \frac{50N}{(0.7m)(0.5m)} = 142.9Pa$$

The uniform normal-stress distribution is shown in Figure 8.

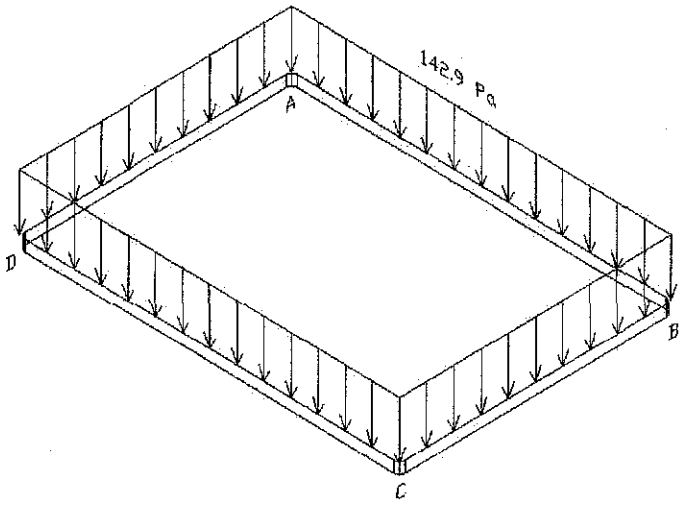


Figure 8: Normal stress distribution on the table top due to normal force

The maximum normal stress due to the bending moment about x-axis is

$$\sigma_{max} = \frac{M_x c_y}{I_x} = \frac{(17.5Nm)(0.35m)}{\frac{1}{12}(0.5m)(0.7m)^3} = 428.6Pa$$

The normal stress distribution for 17.5 Nm moment is shown in Figure 9.

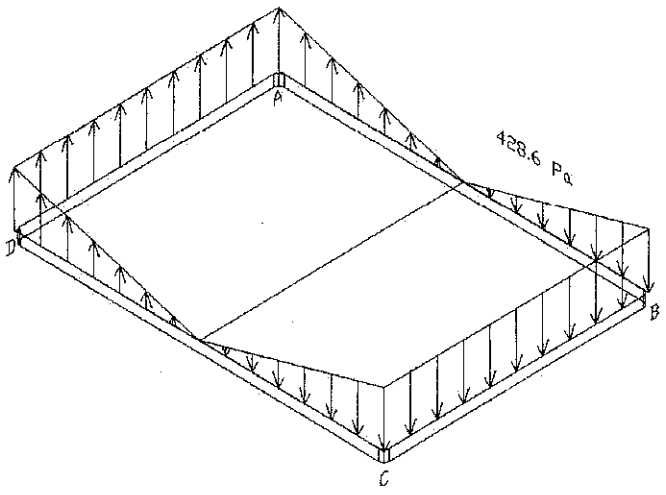


Figure 9:

Normal stress distribution on the table top due to bending moment about x-axis

The maximum normal stress due to the bending moment about y-axis is

$$\sigma_{\max} = \frac{M_y c_x}{I_y} = \frac{(12.5Nm)(0.25m)}{\frac{1}{12}(0.7m)(0.5m)^3} = 428.6Pa$$

The normal stress distribution for 12.5 Nm moment is shown in Figure 10.

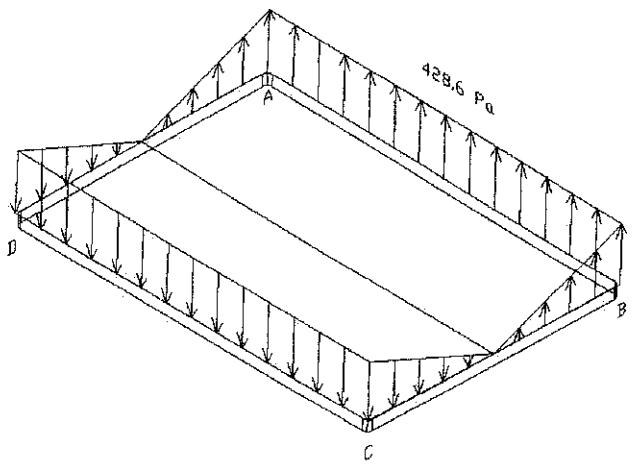


Figure 10:

Normal stress distribution on the table top due to bending moment about y-axis

The normal stress at each point A, B, C and D is been determined by algebraic addition. Assuming that the tensile stress is positive,

Combined loading at corner point

= normal stress due to normal force + total normal stress due to bending moments

$$\sigma_A = [(-142.9) + (+428.6) + (+428.6)]Pa = +714.3Pa$$

$$\sigma_B = [(-142.9) + (-428.6) + (+428.6)]Pa = -142.9Pa$$

$$\sigma_C = [(-142.9) + (-428.6) + (-428.6)]Pa = -1000.1Pa$$

$$\sigma_D = [(-142.9) + (+428.6) + (-428.6)]Pa = -142.9Pa$$

The maximum stress that occurs at point C upon the application of 50 N load is 1000.1 Pa, and this amount is less than the strength of the material selected for the fabrication of prototype, which is wood. The wood's tensile strength is approximately 7.5 MPa [7]. Thus, the load of 50 N applied on the table top won't rupture the table top as well as the link supporting it.

4.6.2 Static Analysis

Static analysis is done to determine the distance of the load application from the anchoring point in order to maintain the stability of the structure upon load application at the extreme point, which is point C of the table top. Figure 11 shows the free body diagram of the analysis.

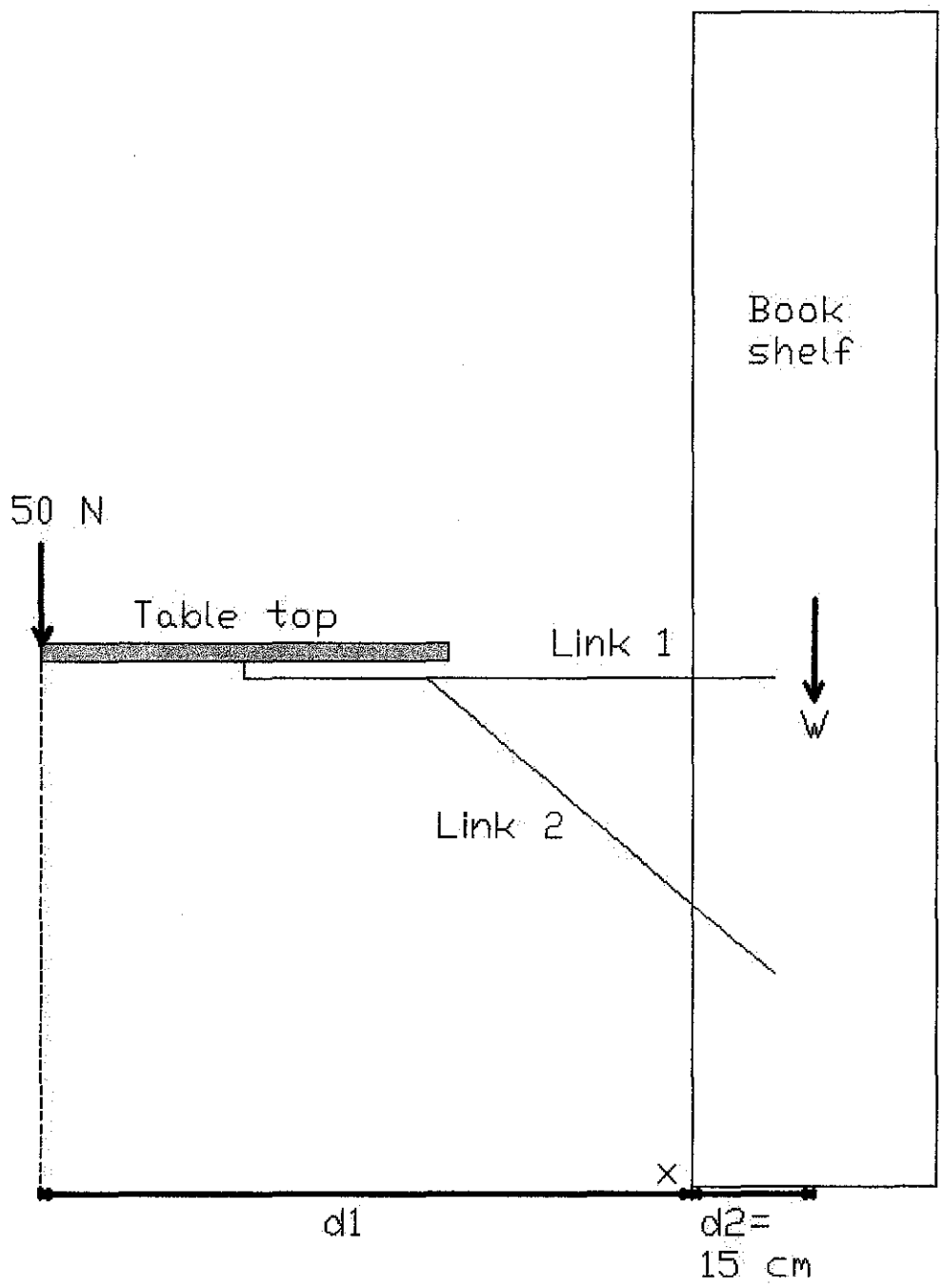


Figure 11: **FBD for static analysis**

In order to determine d_1, the moment that the 50 N load creates about the anchoring point, *x* must equal to the moment that the book shelf's weight, W creates about the anchoring point. When both of these moments are equal to each other, the whole structure maintains its stability upon load application at any points on the table top.

The book shelf's weight without load, W is measured and equals to 20 kg (200 N). The calculation to determine W is as shown:

Dimension of a horizontal tier (w x l x h) = 30 cm x 70 cm x 1.5 cm

Volume of a horizontal tier = 3150 cm^3

Weight of a horizontal tier = 1100 g

Approximate density of the wood

= Weight of a horizontal tier/Volume of a horizontal tier

= 1100 g/3150 cm^3

= 0.35 g/cm^3

The total volume of the book compartment is taken as the volume of all the panels that made up the compartment.

Volume of 2 vertical panels of dimension 30 cm x 138 cm x 1.5 cm = 12420 cm^3

Volume of 2 vertical panels of dimension 70 cm x 65 cm x 2 cm = 18200 cm^3

Volume of 2 horizontal panels of dimension 30 cm x 70 cm x 1.5 cm = 6300 cm^3

Volume of 2 horizontal panels of dimension 30 cm x 70 cm x 5 cm = 21000 cm^3

Total volume, V_T = 57920 cm^3

Weight of the book shelf, W = density of wood x V_T

= 0.35 g/cm^3 x 57920 cm^3

= 20.3 kg

The value of d_1 is been determined based on the relationship below:

Moment of 50 N about x = Moment of W about x

$(50\ N)(d_1) = (W)(15\ cm)$

$d_1 = (W)(15\ cm)/50\ N$

$= (200\ N)(15\ cm)/(50\ N)$

When the above equation is solved, the value of d_1 obtained is 60 cm.

If the distance of load application at point C to the anchoring point is 60 cm, the point where link 1 and link 2 should be attached to the book shelf is found to be 25 cm from the anchoring point x.

The calculation for the above statement is shown below, with the aid of Figure 12.

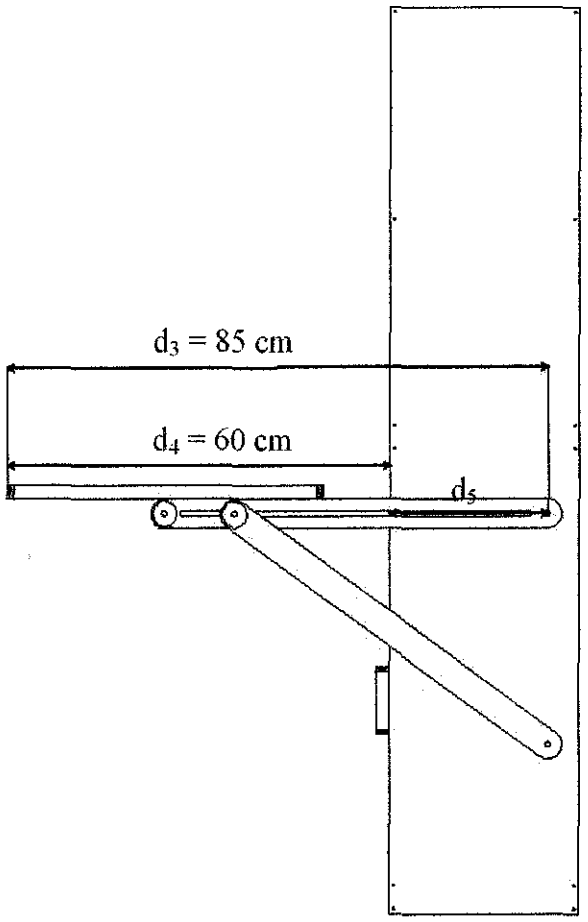


Figure 12:

Distance between the extreme edge of the table top and the point of link attachment on the book shelf to the anchoring point

$d_5 = d_3 - d_4$, where

d_3 = length between the extreme edge of the table top to the centre of bolt's hole of link 1

d_4 = distance between the extreme edge of the table top to the anchoring point

d_5 = distance between the point of attachment of the links measured from the edge of the book shelf

d_5 = (85-60) cm

= 25 cm

Based on this analysis, the engineering drawing of the design was generated and shown in section 4.7.

4.7 Engineering Drawing

4.7.1 Isometric View

The isometric view of the design is shown in Figure 13.

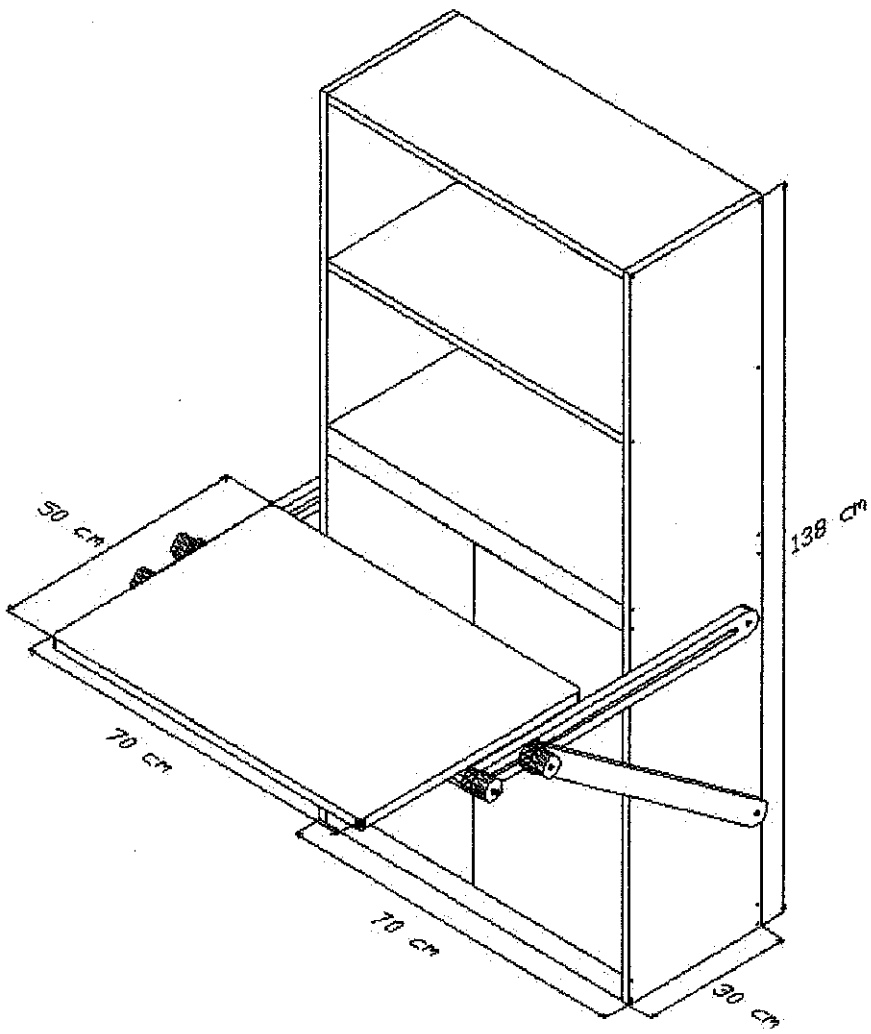


Figure 13: Isometric view

4.7.2 Top View

The top view of the design is shown in Figure 14.

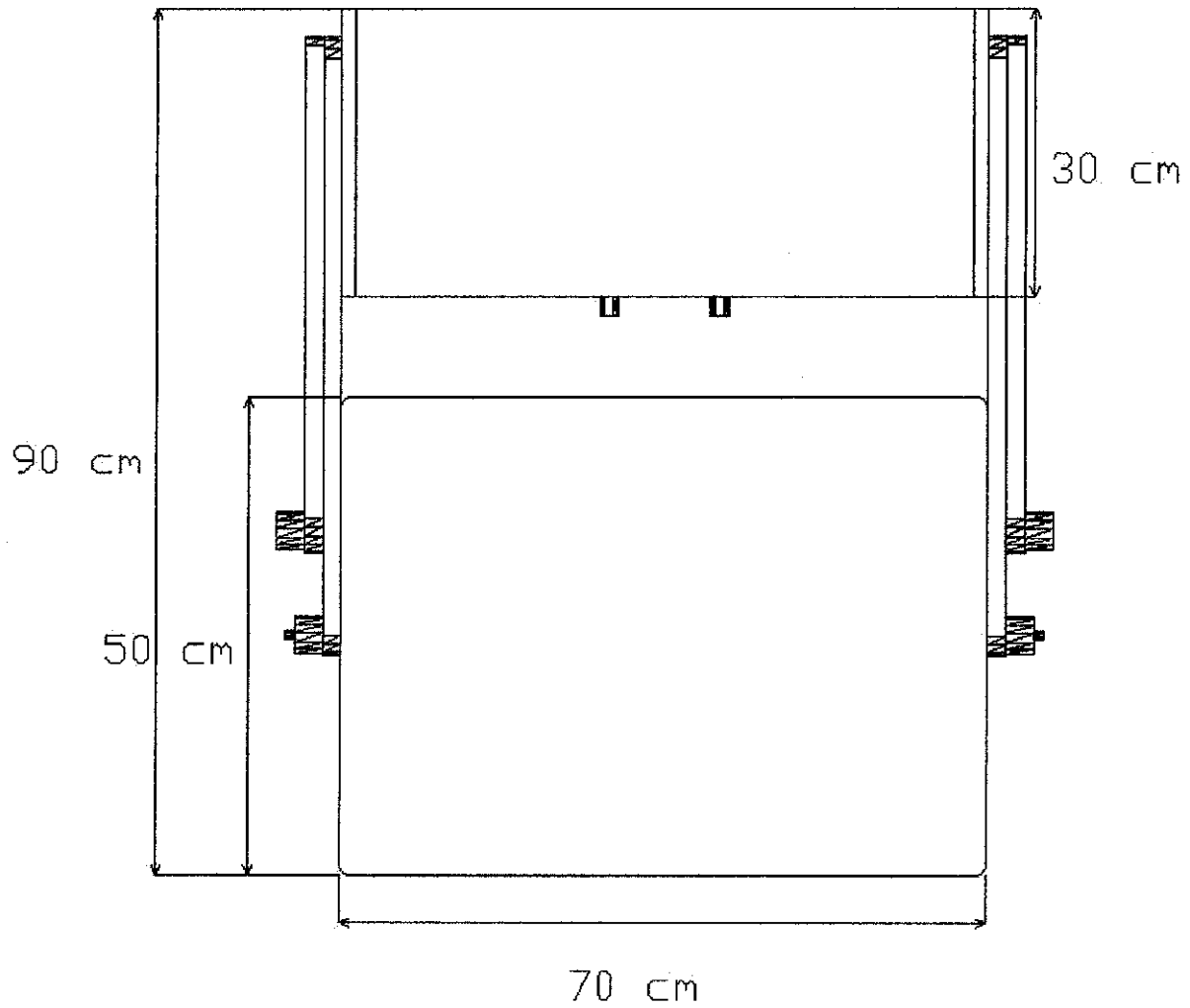


Figure 14: Top view

4.7.3 Front View

The front view of the design is shown in Figure 15.

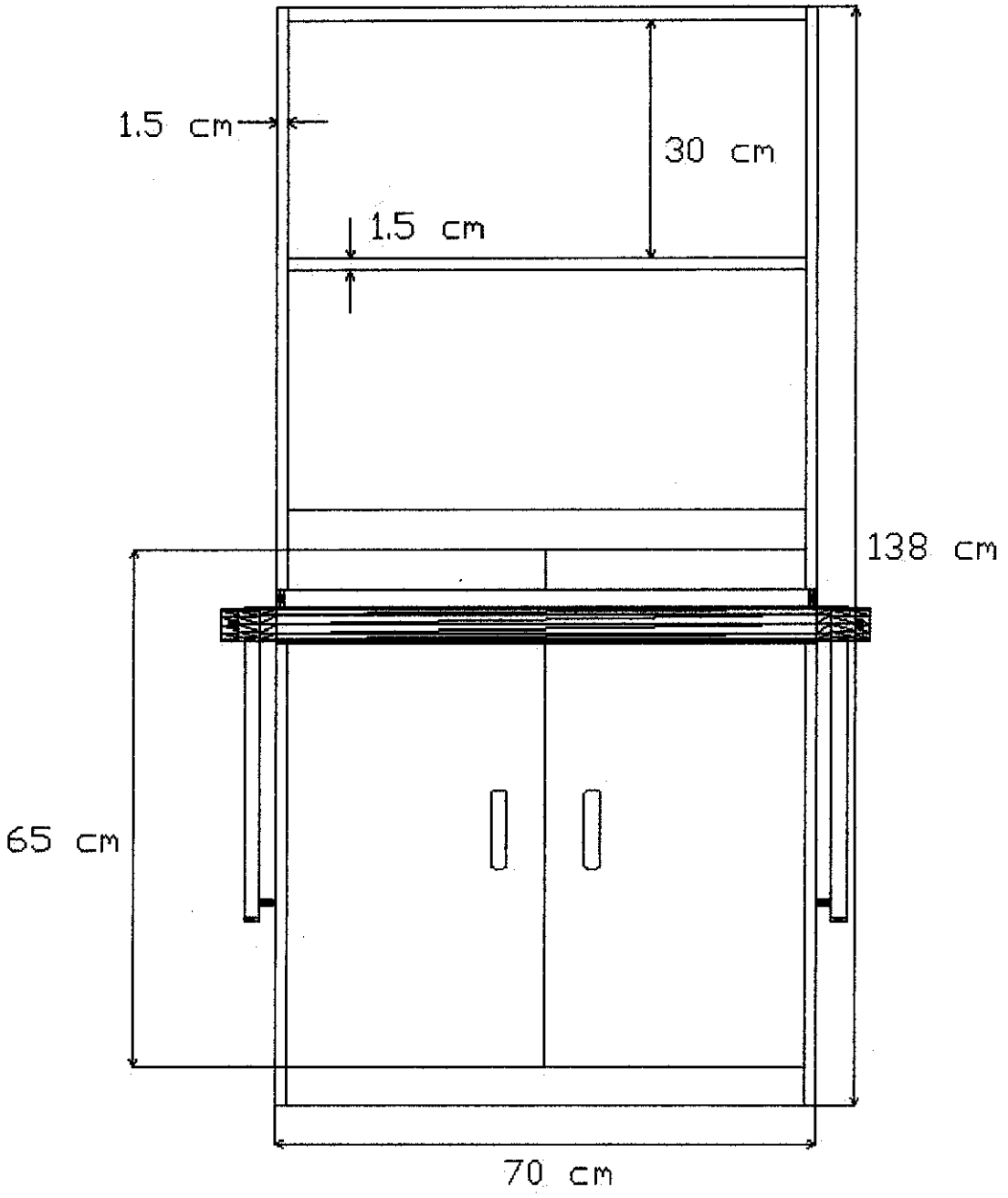


Figure 15: Front view

4.7.4 Side View

4.7.4.1 Side View at Minimum Height

The side view of the design at minimum height is shown in Figure 16.

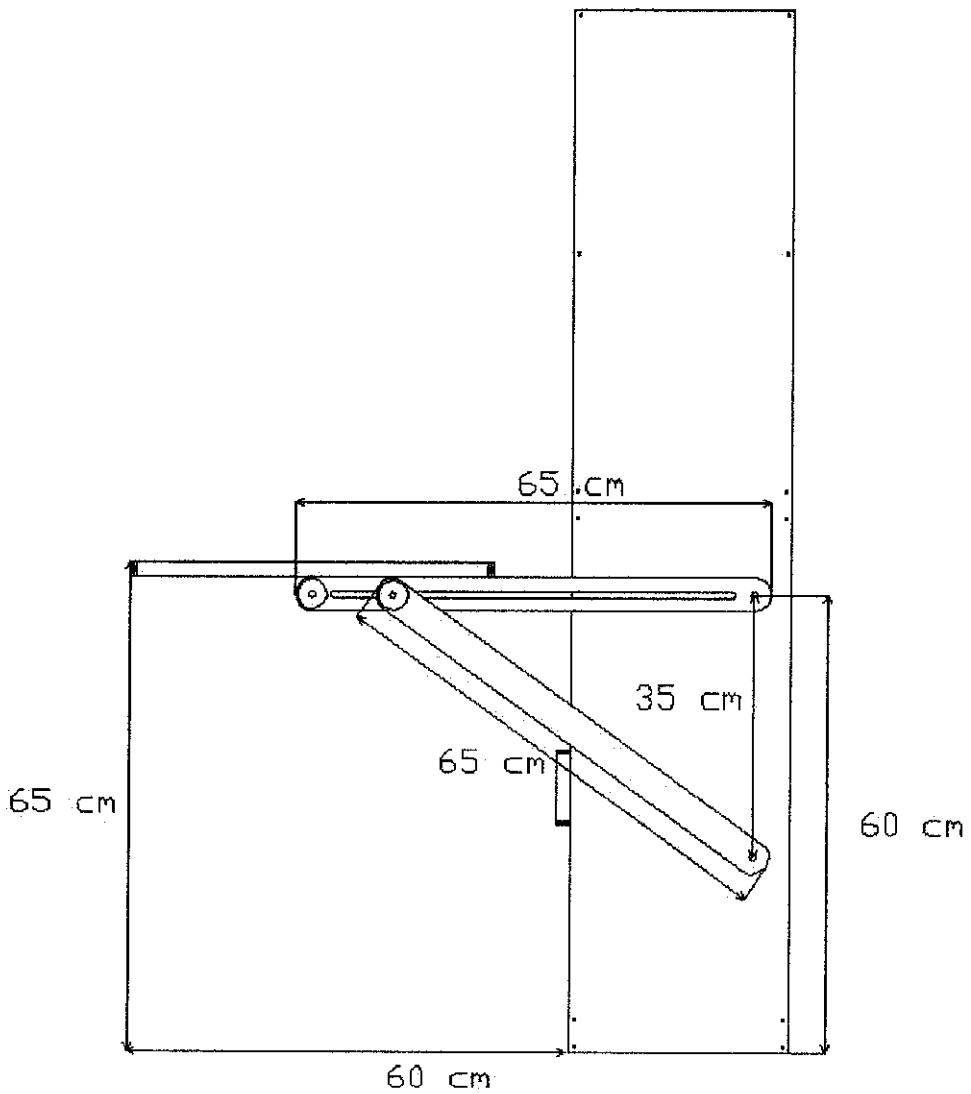


Figure 16: Side view at minimum height

4.7.4.2 Side View at Maximum Height

The side view of the design at maximum height is shown in Figure 17.

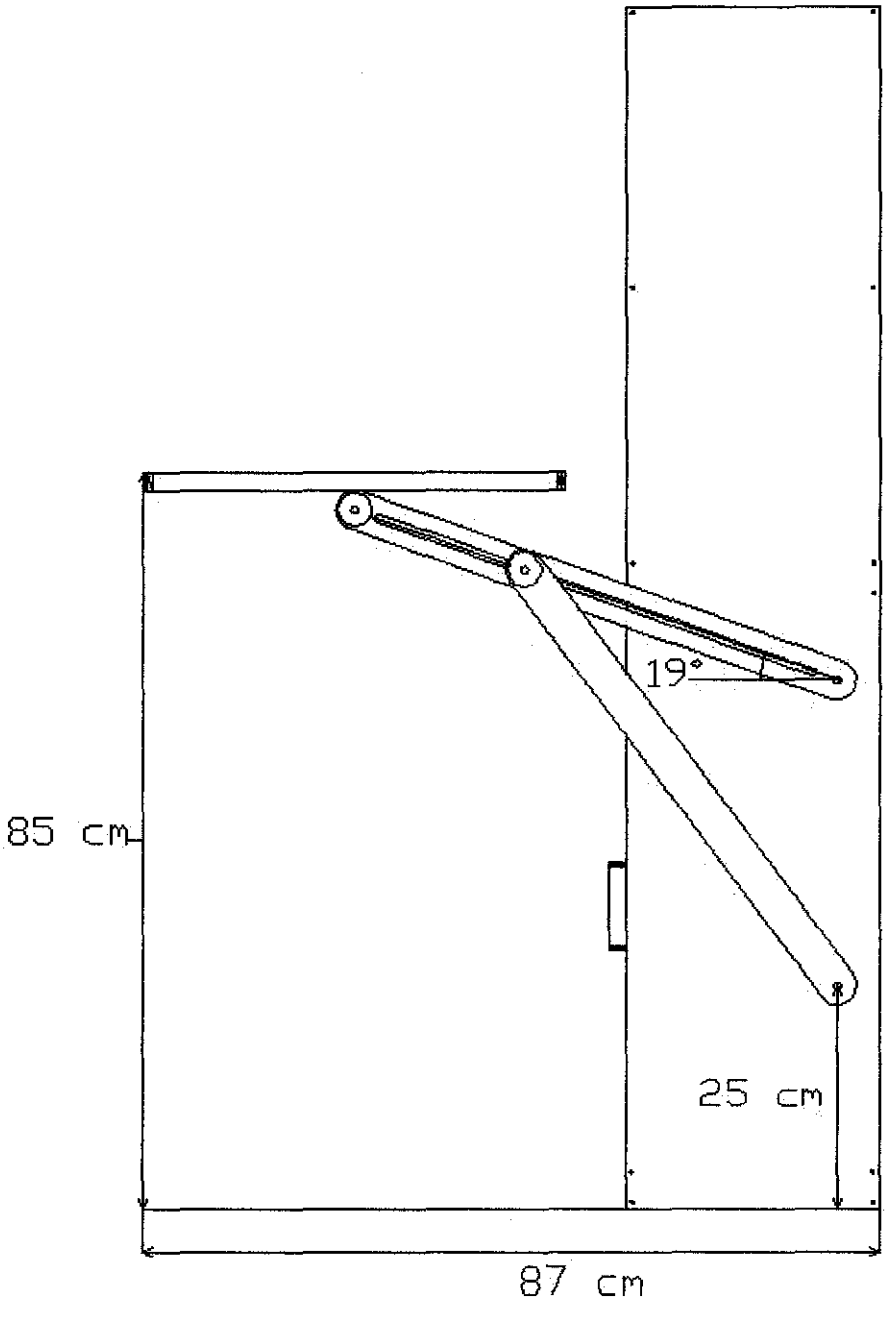


Figure 17: Side view at maximum height

4.7.3.3 Side View with Table Top Tilt at an Angle

The side view of the design with the table top tilt at an angle of 35° from horizontal is shown in Figure 16.

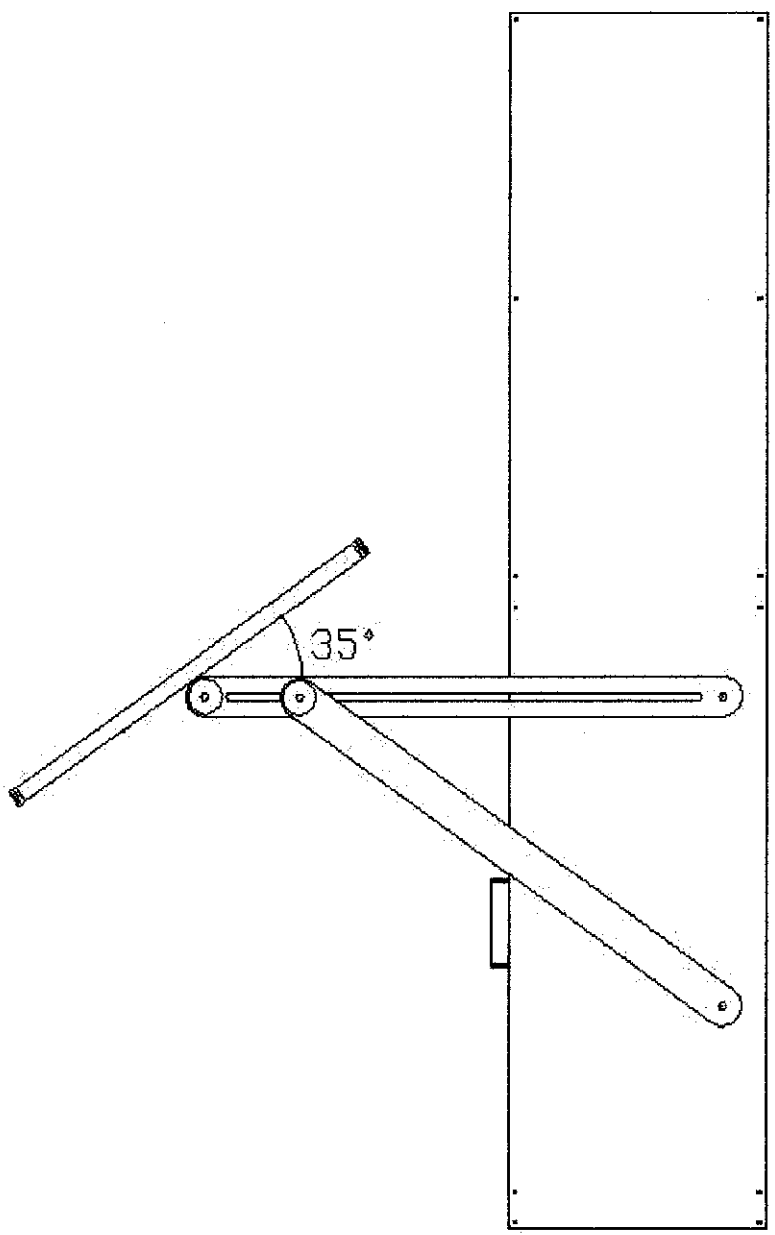


Figure 18: Side view of the table top tilt at an angle

4.8 Proposed Arrangement of the Workstation inside the Room

With reference to Figure 1, it was proposed for the new design of the workstation to be placed at the position of the current study table. The hanging book shelf can be eliminated since the workstation is already equipped with a book shelf that's having 2-tier storage for the frequently used items or equipments and a locker for the storage of less frequently used items. Figure 17 shows the suggestion for the new layout of the hostel room arrangement.

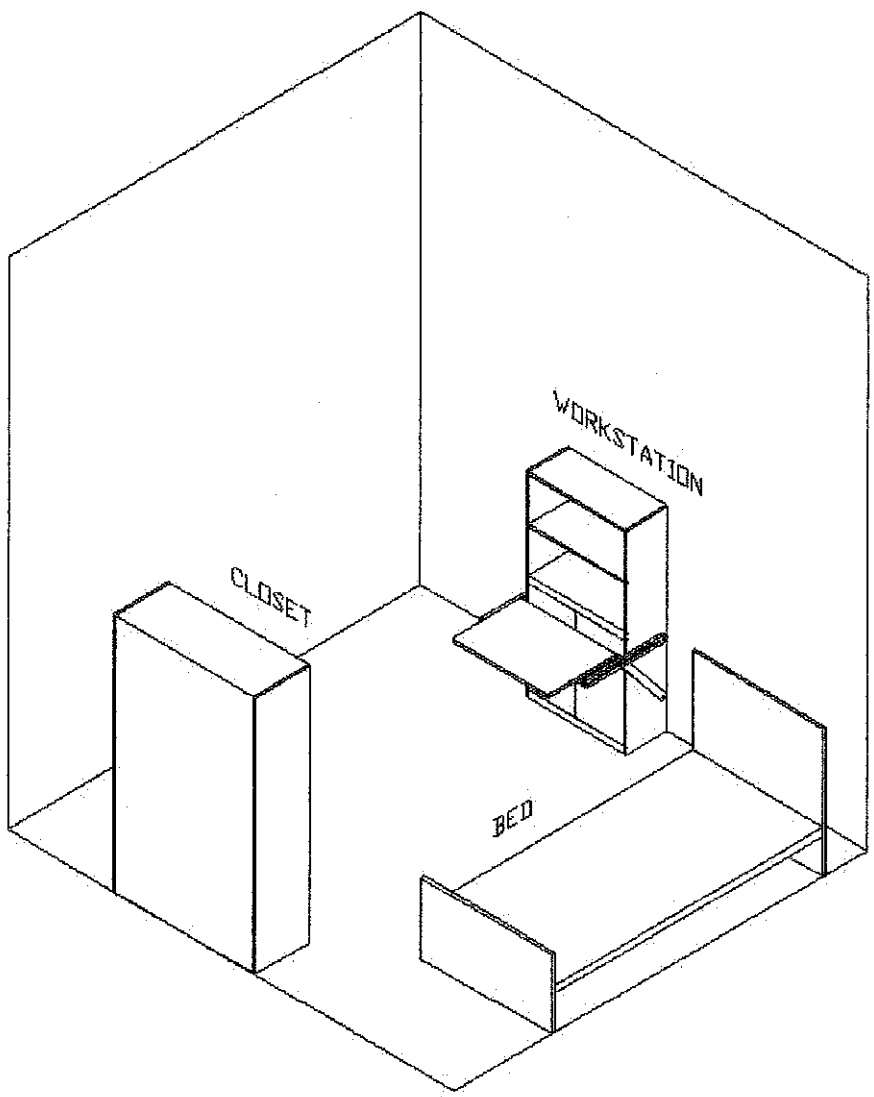


Figure 19: Proposed arrangement of the workstation inside the room

CHAPTER 5

CONCLUSION & RECOMMENDATION

Table with adjustable height differs from the common fixed table in terms of its ability of providing wider range of height selection to the users with respect to an individual requirement. The table allows the users to manipulate its height adjustment feature to fit them comfortably. The manipulation of its elevation off the floor allows the user to work with it both in sitting or standing position, and at the same time providing different amount of leg room and vertical distance from the user to the table top that fit the respective user's needs. The project aims to improve the current workstation provided in one of a local university hostel room in terms of its design. A survey that was done on 80 of the students who reside in the focus hostel block and utilizes the same workstation showed a significant need for the idea of improvement. There were students who do not fit comfortably with the current workstation provided in terms of the available leg room of the study table and the vertical distance between the students to the table top. The proposed ideas from the group of focus in improving the current workstation were being considered and became the goals of the design project, with reference to the established ergonomic guideline in table design. It was decided for the design of the new workstation to consist of a height adjustable table top that can withstand at least the weight of a laptop without jeopardizing its stability and strength and a compartment that can house all of the necessary equipments of the users while performing their intended activity in the workstation. The resulting design is based on the following concepts; the mechanism of height adjustment is achieved by means of bar linkages that are interconnected together with specific configuration where one of the links will slides with respect to another link's movement to give change in the table top's elevation off the floor as required by the user. The table top also can be tilted from complete horizontal to complete vertical to accommodate wide range of user's preference while working with the table. The linkages are attached to a book shelf that houses

the necessary equipments needed by the users in serving their intended purpose. Below is the summary of the design:

Design's title: Table with adjustable height

Height adjustment mechanism: Linkages configuration

Height range: 65 cm to 85 cm off the floor

Tilt adjustment mechanism: Tightening of the support rod that holds the table top

Tilt angle range: Complete horizontal (0° with floor base) to complete vertical (90° with floor base)

Table top dimension: 500 mm x 700 mm x 20 mm

Main material for prototype fabrication: Recycled wood materials

As a conclusion, this project has met its objective that is to design a table that satisfies a wide range of the user's requirement in terms of height and tilt adjustment and the placement of the additional compartment that is kept within the user's reach (distance of 85 cm from the edge of the table top to the back of the book shelf). This project can be continued further by fabricating the prototype and putting the prototype under load test to confirm the engineering design analysis done. Another recommendation is to study on the alternative materials available that can increase the payload of the table top and the alternative designs that utilize the same concept but with improved stability of the structure.

REFERENCES

[1] Bryk, Nancy. http://www.answers.com/topic/table

[2] Article published by Canadian Centre for Occupational Health and Safety, 2006 http://www.jobaccess.gov.au

[3] Article published by San Francisco State University, 2007, Ergonomic Guidelines http://www.sfsu.edu/~ergo/guidelines/ergo_long.html

[4] www.ergoindemand.com

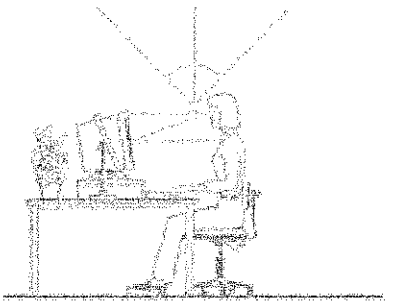
[5] www.uptimebusinessproducts.com

[6] www.flaghouse.com

[7] Lardner, T. and Archer, R. 1994. Mechanics of Solid An Introduction, United States of America, McGraw Hill, Inc.

APPENDIX 1

The purpose of this survey is to observe the condition of the current study table used in your hostel room. Simply underline your respective responses.



Q1: When you are in the shown sitting position, does the upper side of your leg touches the bottom surface of the table? (Yes/No)

Q2: Are you comfortable with the height of the table? (Yes/No)

If no, is the table too high or too short for you? (High/Short)

Q3: Is the table top area capable of accommodating all your necessary equipments? (laptop/PC/printer/stationeries holder/book shelf) (Yes/No)

If no, is your workstation equipped with a side compartment to house all of your necessary equipments? (Yes/No)

Were you being able to reach for the equipments at the side compartment without standing up from your chair? (Yes/No)

APPENDIX 2

FYP 2 Gantt Chart