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FABRICATION & ANALYSIS OF MECHANICALLY OPERATED ROTATIONAL SCISSORS LIFT

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Abstract:

This project describes the information about fabrication of a simple mechanical rotational scissor lift. Conventionally a scissor lift or jack is used for lifting heavy loads with less effort mainly in industries or any other fields where loads are lifted. It can be of mechanical, pneumatic or hydraulic type. The matter described in the paper is developed keeping in mind that the lift can be operated by mechanical means so that effort required to operate is less for lifting more weight. Also such design can make the lift more compact and much suitable for medium scale work. In our project we added a feature of rotating the Scissor lift top table. This paper also gives information on how scissor lift works with different means (ex-mechanical, pneumatic and hydraulic), basic information about worm, rack and pinion, types of lifts, advantages of the scissor lift, different types of gears, gear nomenclature ,threads and scissor arms.

1.1 INTRODUCTION TO SCISSORS LIFT:

A scissor lift or mechanism is a device used to extend or position a platform by mechanical means. The term “scissor” comes from the mechanic which has folding supports in criss cross “X” pattern. The extension or displacement motion is achieved by the application of force to one or more supports, resulting in an elongation of the cross pattern. The force applied to extend the scissors mechanism may by hydraulic, pneumatic or mechanical (via a lead screw or rack and pinion system).

The need for the use of lift is very paramount and it runs across labs, workshops, factories, residential/commercial buildings to repair street lights, fixing of bill boards, electric bulbs etc. expanded and less-efficient, the engineers may run into one or more problems when in use.

The name scissors lift originated from the ability of the device to open (expand) and close (contract) just like a scissors. Considering the need for this kind of mechanism, estimating as well the cost of expanding energy more that result gotten as well the maintenance etc. it is better to adopt this design concept to the production of the machine.

The initial idea of design considered was the design of a single hydraulic ram for heavy duty vehicles and putting it underneath.It was rather found out that; there is a possibility of the individual ascending/descending, to be controlling the device himself. Therefore further research was made to see how to achieve this aim.

Before this time scissors lift existing use hydraulic or rope system powered by batteries for its operations. Several challenges were encountered in this very design. Some amongst many include; low efficiency, risk of having the batteries discharged during an emergency, extended time of operation, dependent operation, as well as maintenance cost. It is the consideration of these factors that initiated the idea of producing this mechanically powered scissors lift with independent operator. The idea is geared towards producing a scissors lift using one rack and pinion placed across flat, in between two cross frames connected to a motor. Also, the individual ascending / descending is still the same person controlling it.

A scissors lift is attached to a piece of equipment having a work station known as scissors lift table that houses gear arrangement, the dc motor, the rectifier, and connections of the motor. A scissors lift does not go as high as a boom lift, it sacrifices heights for a large work station. Where more height is needed, a boom lift can be used.

1.2 STATEMENT OF THE PROBLEM:

A problem remains a problem until a solution is proffered. With the limitations encountered in the use of ropes, ladders, scaffold and mechanical scissors lifts in getting to elevated height such as the amount of load to be carried, conformability, time consumption, much energy expended etc. the idea of a hydraulically powered scissors lift which will overcome the above stated limitations is used.

1.3 SCOPE OF THE STUDY:

The design and construction of the mechanicall scissors lift is to lift up to a height of 3.2m and carrying capacity of less than 500kg (500 kilograms) with the available engineering materials. However, there is for academic purpose, a similar project for general carrying – capacity with a selection of better engineering materials.

1.4 IMPORTANCE SIGNIFICANCE OF THE STUDY:

The design and construction of a hydraulic scissors lift is to lift a worker together with the working equipment comfortably and safely to a required working height not easily accessible. It may be used without a necessary external assistance or assistance from a second party due to the concept of the design. This project will be an important engineering tool or device used in maintenance jobs. Changing of street lights, painting of high buildings and walls around the school environment.

1.5 AIMS/OBJECTIVES OF THE STUDY:

The project is aimed at designing and constructing a mechanically powered scissors lift to lift and lowers worker and his working equipment with ease and in the most economical way. The lift is expected to work with minimal technical challenges and greater comfort due to its wide range of application. The device can easily be handled to the site to be used with a tow-van and then powered by a generator. Between the heights of lift (i.e. the maximum height) the device can be used in any height within this range and can be descend immediately in case of emergency, and can be operated independent of a second party.

2. LITERATURE REVIEW:

In order to perform this project, literature review has been made from various sources like journal, books and others. This chapter includes all important studies which have been done previously by other research work. It is importance to do the literature review before doing the project because we can implement if there are information that related to this project. The most important thing before starting the project we must clearly understand about the topic that we want to do. So by doing the literature review we can gain knowledge to make sure we fully understand and can complete the project. A review of the article was performed to identify studies that relevant to the topic. The search to find material that related to the topic is categories as scissors links, dc motor,rectifier, electric switch etc.

2.1 PRINCIPLE OF OPERATION OF A HYDRAULIC LIFT:

(EXTENSION ANDCONTRACTION)

A scissors lift is a type of platform that can usually only move vertically. The mechanism to achieve this is the use of linked, folding supports in a criss-cross “X” pattern, known as a scissors mechanism. The upward motion is achieved by the application of pressure to the outer side of the lowest set of supports, elongating the crossing pattern and prepelling the work platform vertically. The platform may also have extending “bridge” to allow closer access to the work area, because of the inherent limits of vertical – only movement. The contraction of the scissor action can be hyrdaulic, pneumatic or mechanical (via a leadscrew or rack and pinion system), but in this case, it is mechanical. Depending on the power system employed on the lift; it may require no power to enter “desert” mode, but rather a simple release ofrack and pinion. This is the main reason that these methods of powering the lift (mechanically) is preferred, as it allows a fail – safe option of returning the platform to the ground by release of a manual valve.

(ROTATION AND SLIDING)

If we really need an rotation or sliding motion of the top platform of the lift then we need to mount a platform with the help of a connecting rod or a nut and bolt mechnanism but in this project we prefer nut and bolt because of the easy mouting, and the platform which is going to be mouted is attatched with a wheels they can provide the rotation as well as sliding of the platform easily in the place of wheels we can provide worm wheel or ball bearings arrangement.

MAIN COMPONENTS OF ROTATIONAL SCISSORS LIFT:

3.1 RACK AND PINION:

A **rack and pinion** is a type of linear actuator that comprises a circular gear (the *pinion*) engaging a linear gear (the *rack*), which operate to translate rotational motion into linear motion. Driving the pinion into rotation causes the rack to be driven linearly. Driving the rack linearly will cause the pinion to be driven into a rotation.

For example, in a rack railway, the rotation of a pinion mounted on a locomotive or a railcar engages a rack between the rails and forces a train up a steep slope.

For every pair of conjugate involute profile, there is a basic rack. This basic rack is the profile of the conjugate gear of infinite pitch radius (i.e. a toothed straight edge).

A generating rack is a rack outline used to indicate tooth details and dimensions for the design of a generating tool, such as a hob or a gear shaper cutter.

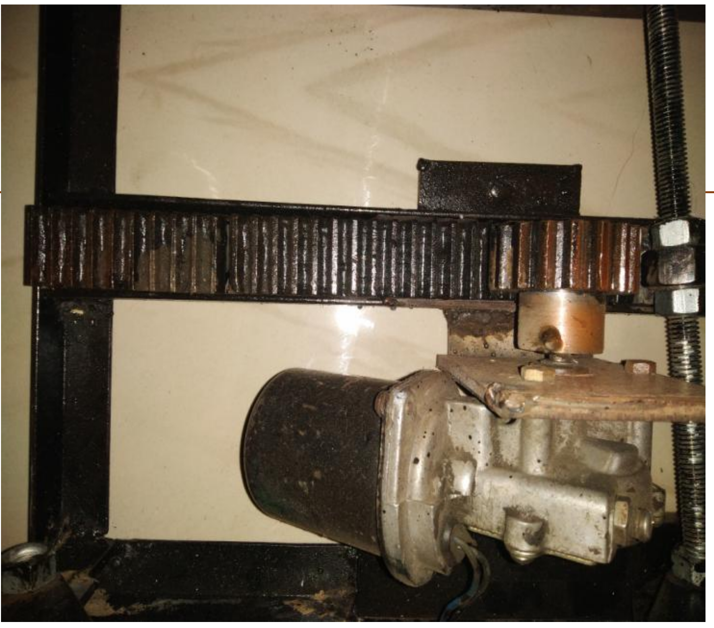


FIG: RACK AND PINION

3.2 MOTOR:

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

DC motors were the first form of motor widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills.

Here we use 12v car viper dc motar which is coupled to the rack and pinion,so that the motion of pinion is possible by coverting electrical energy into mechanical energy.

FIG: 12V CAR VIPER DC MOTOR

3.3 AC – DC CONVERTER:

In electrical engineering, power engineering, and the electric power industry, power conversion is converting electric energy from one form to another such as converting between AC and DC, or changing the voltage or frequency; or some combination of these. A power converter is an electrical or electro-mechanical device for converting electrical energy. This could be as simple as a transformer to change the voltage of AC power, but also includes far more complex systems. The term can also refer to a class of electrical machinery that is used to convert one frequency of alternating current into another frequency.

FIG: AC – DC CONVERTER

3.4 DETAILED SKETCH:

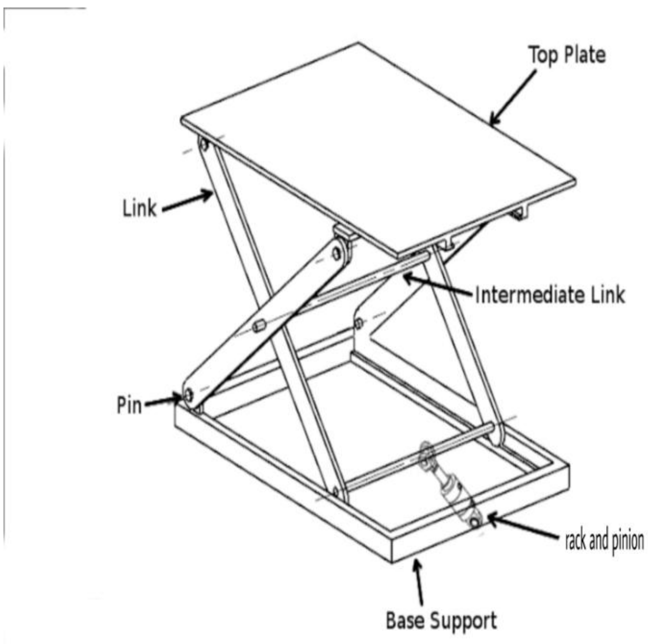


FIG: DETAILED SKETCH OF SCISSORS LIFT

3.5 **SCISSORS LEGS:**

Leg deflection due to bending is a result of stress, which is driven by total weight supported by the legs, scissors leg length, and available leg cross section. The longer the scissors legs are, the more difficult it is to control bending under load. Increased leg strength via increased leg material height does improve resistance to deflection, but can create a potentially undesirable increased collapsed height of the lift.

FIG: SIDE VIEW SHOWING SCISSORS LEGS

3.6 BASE FRAME:

The base frame of the equipment is made up of mild steel material having density 7.85 gr/cm3. Normally, the lift's base frame is mounted to the floor and should not experience deflection. For those cases where the scissors lift is mounted to an elevated or portable frame, the potential for deflection increases. To effectively resist deflection, the base frame must be rigidly supported from beneath to support the point loading created by the two scissors leg rollers and the two scissors leg hinges.

3.7 LOAD PLACEMENT:

Load placement also plays a large part in scissors lift deflection. Off-centered loads cause the scissors lift to deflect differently than with centered or evenly distributed, loads. End loads (in-line with the scissors) are usually shared well between the two scissors leg pairs. Side loads (perpendicular to the scissors), however, are not shared as well between the scissors leg pairs and must be kept within acceptable design limits to prevent leg twist (unequal scissors leg pair deflection) – which, in addition to platform movement due to deflection, often results in poor roller tracking, unequal axle pin wear, and misalignment of cylinder mounts.

3.8 CAD MODEL SHOWING SCISSORS LINKS AND GEARS:

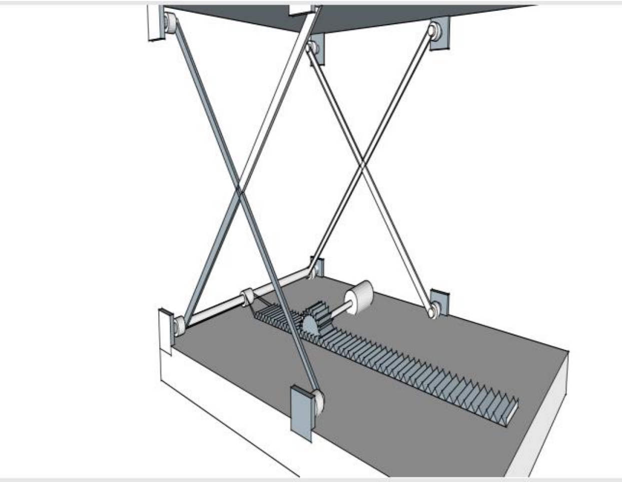


FIG: MODEL SHOWING SCISSORS LINKS AND GEARS

3.9 FINAL CAD MODEL:

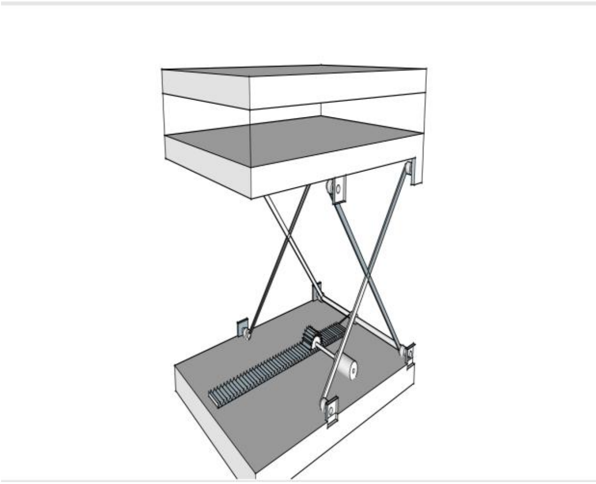


FIG: FINAL CAD MODEL

4.1 FABRICATION OF ROTATIONAL SCISSORS LIFT:

The Equipment is completely made up of mild steel material which is having density 7.85gr/cm3. Rack and pinon is coupled with a connecting rod is driven by a car viper motar of 12volt dc source. Two rollers are connected to the both the ends of connecting rod at the base frame. With the help of nuts and bolts scissors links are connected to the base as well as platform. A wheel arrangement is used in order to get the rotary motion as well as sliding motion of the top platform which is connected to the main platform with the help of temporary hand tight nut and bolt assembly. Sheet metal is welded to the both platforms inorder to place the load comfortablly.

FIG: ROTATIONAL SCISSORS LIFT

4.2 WORKING:

A scissors lift is a type of platform that can usually only move vertically. The mechanism to achieve this is the use of linked, folding supports in a criss-cross "X" pattern, known as a scissors mechanism. The upward motion is achieved by the application of pressure to the outer side of the lowest set of supports, elongating the crossing pattern and prepelling the work platform vertically. The platform may also have extending "bridge" to allow closer access to the work area, because of the inherent limits of vertical – only movement. The contraction of the scissor action can be hydrdaulic, pneumatic or mechanical (via a leadscrew or rack and pinion system), but in this case, it is mechanical. Depending on the power system employed on the lift; it may require no power to enter "desert" mode, but rather a simple release ofrack and pinion. This is the main reason that these methods of powering the lift (mechanically) is preferred, as it allows a fail – safe option of returning the platform to the ground by release of a manual valve.

(ROTATION AND SLIDING)

If we really need an rotation or sliding motion of the top platform of the lift then we need to mount a platform with the help of a connecting rod or a nut and bolt mechnanism but in this project we prefer nut and bolt because of the easy mouting, and the platform which is going to be mouted is attatched with a wheels they can provide the rotation as well as sliding of the platform easily in the place of wheels we can provide worm wheel or ball bearings arrangement.

Total no.of teeth on the rack = 33

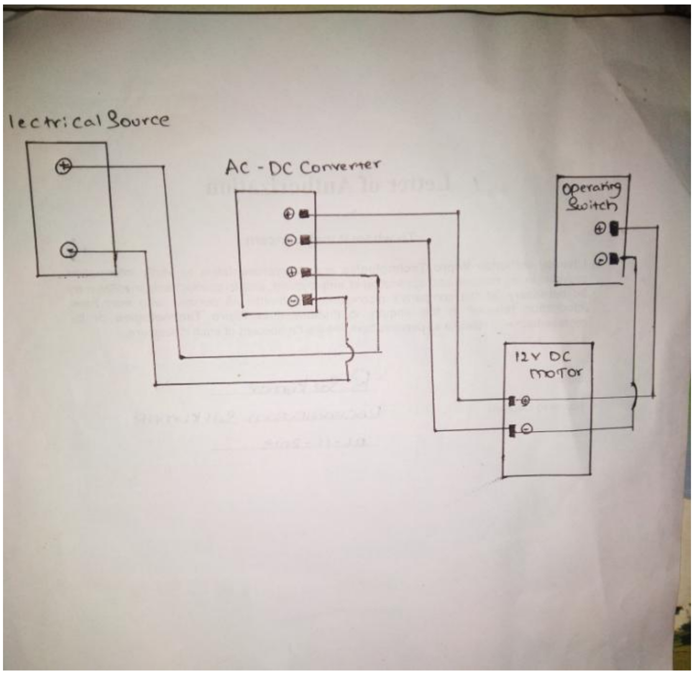
Total no.of teeth over the pinion = 18

When ever pinion travells from 1st tooth of the rack to 27th tooth then we get maximum lift.

Maximum total Lift = 415 mm + 70mm (Rotary mounting height).

Initial Position = 150mm + 70mm (Rotary mounting height).

4.3 CIRCUIT DIAGRAM:



5.1 STATIC EQUATIONS:

At position 1

A) Bending moment at point B (CCW) $\sum M_B = w/2 * 2L*\cos\theta - F_Y * L * \cos\theta - F_X * L*\sin\theta$
B) Force at X $\sum F_X = 0 = F_X - R_{X1}$
C) Force at X $\sum F_Y = 0 = -w/2 + F_Y - R_{Y1}$

At position 2

D) Bending moment at point A (CCW) $\sum M_A = 0 = w/2*2L\cos\theta - F_Y*L*\cos\theta + F_X*L*\sin\theta$
E) Force at X $\sum F_X = 0 = -F_X + R_{X2}$
F) Force at X $\sum F_Y = 0 = -w/2 - F_Y + R_{Y2}$

There are 6 unknown equations and 6 unknowns the solutions are as follows

A) $0 = w/2 * 2L*\cos\theta - F_Y * L * \cos\theta - F_X * L*\sin\theta$

$$F_Y = -\frac{w/2*2L*\cos\theta}{L*\cos\theta} + \frac{F_x*L*\sin\theta}{L*\cos\theta}$$

$F_Y = -w + F_X * \tan\theta$

D) $0 = -w/2 * 2L*\cos\theta - F_Y * L * \cos\theta - F_X * L*\sin\theta$

$$F_X = \frac{w/2*2L*\cos\theta}{L*\sin\theta} - \frac{F_x*L*\cos\theta}{L*\sin\theta}$$

$F_X = w/\tan\theta - F_Y/\tan\theta$

By substituting equations A in D

$F_X = w/\tan\theta - (-w/\tan\theta - F_x{*}\tan\theta/\tan\theta)$
$F_X = 2w/\tan\theta + F_X$
$F_x = w/\tan\theta$

If $-R_{X1}+F_X=0$ and $R_{X2}-F_X=0$
$R_{x1} = F_X$ $R_{x2} = F_X$

Therefore $R_{X1} = R_{X2} = w/\tan\theta$

A) $-w+F_x{*}\tan\theta=F_Y$

D) $w/\tan\theta - F_Y/\tan\theta = F_X$

$F_Y = -w + (w/\tan\theta - F_Y/\tan\theta) * \tan\theta$

$F_Y = -F_Y$

$F_Y = 0$

For calculating upward reactions

F) ɫ $= -w/2 - F_Y{*}0 + R_{Y2}$
$w/2 = R_{Y2}$

C) ɫ $= -w/2 + F_Y{*}0 + R_{Y1}$
$w/2 = R_{Y1}$

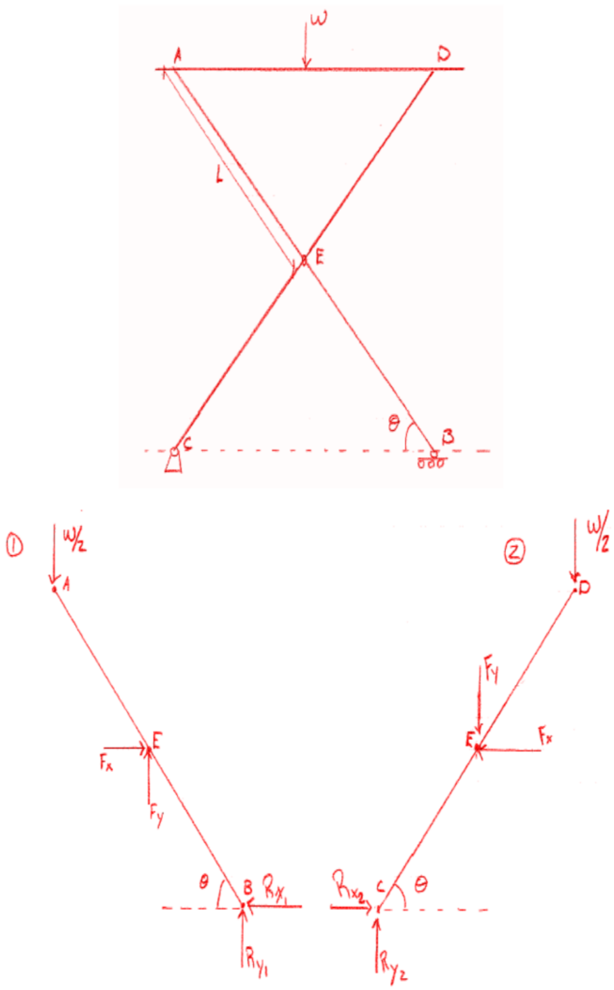


FIG: FREE BODY DIAGRAMS

At position 1

G) Bending moment at point B (CCW) $\sum M_B = w/2 * 2L*\cos\theta - F_Y * L * \cos\theta - F_X * L*\sin\theta$
H) Force at X $\sum F_X =$ ł $= F_X - R_{X1}$
I) Force at X $\sum F_Y =$ ł $= -w/2 + F_Y - R_{Y1}$

At position 2

J) Bending moment at point A (CCW) $\sum M_A =$ ł $= w/2*2L\cos\theta - F_Y*L*\cos\theta + F_X*L*\sin\theta$
K) Force at X $\sum F_X =$ ł $= -F_X + R_{X2}$
L) Force at X $\sum F_Y =$ ł $= -w/2 - F_Y + R_{Y2}$

There are 6 unknown equations and 6 unknowns the solutions are as follows

B) $0 = w/2 * 2L*\cos\theta - F_Y * L * \cos\theta - F_X * L*\sin\theta$

$$F_Y = -\frac{w/2*2L*\cos\theta}{L*\cos\theta} + \frac{F_x*L*\sin\theta}{L*\cos\theta}$$

$F_Y = -w + F_X * \tan\theta$

In conclusion

$\mathbf{R_{X1} = R_{X2} = w/\tan\theta}$

$\mathbf{F_X = w/\tan\theta}$

$\mathbf{R_{Y1} = R_{Y2} = w/2}$

$\mathbf{F_Y = 0.}$

WITH OUT PLACING ANY LOAD:

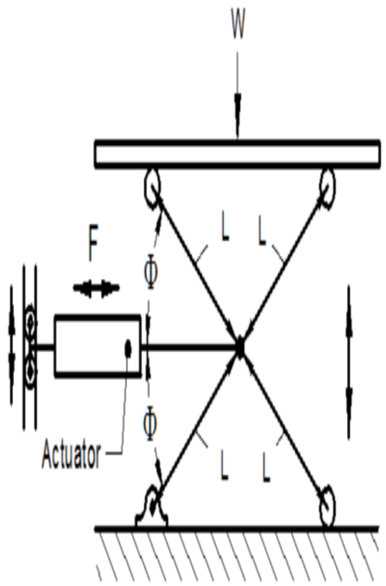


FIG: SCISSORS LIFT WITH LOAD APPLIED AT CENTER PIN

Variables	
Weight Payload & Platform W (N,lbs) =	84.14
Angle Ø (Degrees) =	40
Results	
Force for Equilibrium at Load Rx (N.lbs)	100.27
Load Ry (N.lbs)	42.07
Here weight of the platform = 8.58 × 9.81 =84.14	

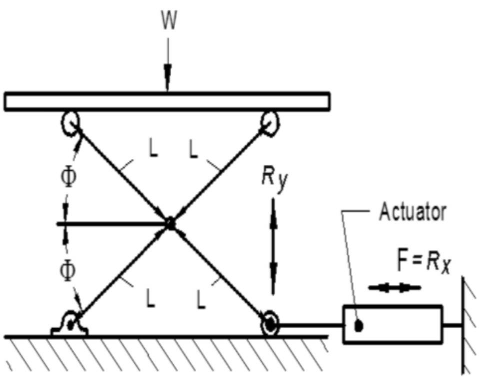


Fig : SCISSORS LIFT EQUATION WITH LOAD APPLIED APPLIED AT BOTTOM

Variables	
Weight Payload & Platform W (N,lbs) =	84.14
Angle Ø (Degrees) =	45
Results	
Force for Equilibrium at Load R_x (N.lbs)	84.14
Load R_y (N.lbs)	42.07
Here weight of the platform = 8.58 × 9.81 =84.14	

After Placing 20kg of Load:

Variables	
Weight Payload & Platform W (N,lbs) =	84.14
Angle Ø (Degrees) =	45
Results	
Force for Equilibrium at Load R_x (N.lbs)	84.14
Load R_y (N.lbs)	42.07
Here weight of the platform = 8.58 × 9.81 =84.14	

LOAD APPLIED AT CENTER PIN:

VARIABLES	
Weight Payload & Platform W (N, lbs)	280.37
Angle Ø (Degrees)	40.00
RESULTS	
Force for Equilibrium at Load R_x (N, lbs)	334.13
Load R_y (N, lbs)	140.19

APPLIED APPLIED AT BOTTOM:

VARIABLES	
Weight Payload & Platform W (N, lbs)	280.37
Angle Ø (Degrees)	45.00
RESULTS	
Force for Equilibrium at Load Rx (N, lbs)	280.37
Load Ry (N, lbs)	140.19

CONCLUSION:

The design and fabrication of a portable work platform elevated by a rack and pinion was carried out meeting the required design standards. The portable work platform is operated by rack and pinion which is operated by a motor. The scissor lift can be design for high load also if a suitable high capacity hydraulic cylinder is used. The hydraulic scissor lift is simple in use and does not required routine maintenance. It can also lift heavier loads. The main constraint of this device is its high initial cost, but has a low operating cost. The shearing tool should be heat treated to have high strength. Savings resulting from the use of this device will make it pay for itself with in short period of time and it can be a great companion in any engineering industry dealing with rusted and unused metals.

RECOMMENDATION:

This device affords plenty of scope for modifications for further improvements and operational efficiency, which should make it commercially available and attractive. Hence, its wide application in industries, hydraulic pressure system, for lifting of vehicle in garages, maintenance of huge machines, and for staking purpose. Thus, it is recommended for the engineering industry and for commercial production

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