American University of Beirut

Faculty of Engineering

Department of Mechanical Engineering

Mech 332 | Project

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Hydraulic Press in a Scissor Mechanism

Spring 2023

Date: 28 april, 2023

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Introduction/Project Description

Hydraulic scissor lifts are an essential lifting mechanism in a range of industries, including construction, manufacturing, and warehousing. They are a type of hydraulic lift that uses a scissor-like mechanism to raise and lower heavy loads vertically. A hydraulic scissor lift is a versatile and powerful lifting solution that can be customized to suit specific applications, making it an indispensable tool for many businesses. This project description will provide an overview of a hydraulic scissor lift's main components and how they work together to lift heavy loads safely and efficiently.

The project involves designing and building a scissor lift with hydraulic cylinders.

The design of the scissor lift will involve selecting the appropriate materials and components, including the hydraulic cylinders, pump, and control system. The lift will need to be able to handle a specified weight capacity and be designed to operate safely in different weather conditions.

The construction phase will involve assembling the metal frame of the scissor lift and installing the hydraulic cylinders and other components. The control system will also need to be installed and tested to ensure that the lift can be operated safely and efficiently.

Once the lift is built, it will need to be tested to ensure that it can handle the specified weight capacity and operate safely in different conditions. The lift should be able to raise and lower smoothly and quietly, and the control system should be intuitive and easy to use.

Overall, the project will require a range of skills, including mechanical design and fabrication, hydraulic system design and installation, and electrical system design and installation. The final result should be a reliable, safe, and efficient scissor lift that can be used in a range of applications.

Identification, Dissection

In our case, the hydraulic scissor lift mechanism is made up of:

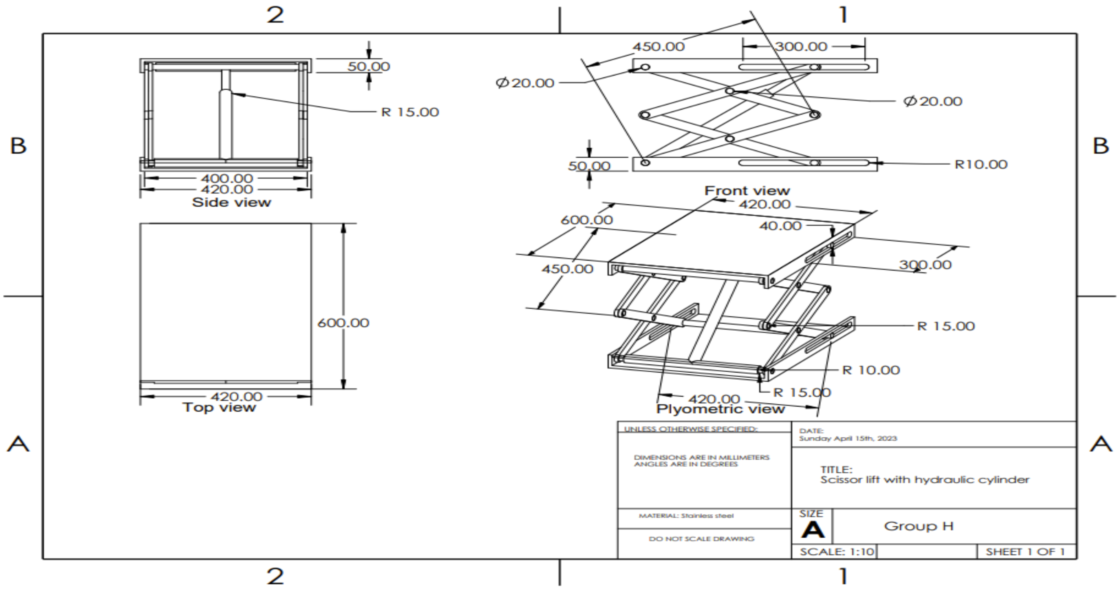
1. Platform: This is the part of the hydraulic scissor lift where workers or materials stand.
2. Scissor arms: The scissor arms are the primary lifting mechanism of the scissor lift.
3. Hydraulic cylinder: The hydraulic cylinder is responsible for providing the force that extends and collapses the scissor arms.
4. Base: The base of the scissor lift is the foundation on which the entire mechanism is built.
5. Hydraulic pump: The hydraulic pump is used to pressurize the hydraulic fluid that powers the hydraulic cylinder. It typically includes a reservoir, a pump, and a control valve.

These components are attached using joints.

Sometimes, the hydraulic scissor lift could have:

- A Control panel: The control panel is the interface through which the operator controls the movement of the hydraulic scissor lift. It typically includes buttons or a joystick to move the platform up and down.
- Wheels and axles: Some hydraulic scissor lifts are mounted on wheels to allow them to be easily moved from one location to another.
- Stabilizing legs: Some hydraulic scissor lifts have stabilizing legs that can be extended to provide additional stability while the platform is elevated.
- Safety features: Hydraulic scissor lifts may also include safety features such as guardrails, emergency stop buttons, and tilt sensors to prevent accidents and ensure worker safety.

Dimensions



Calculations and Analysis

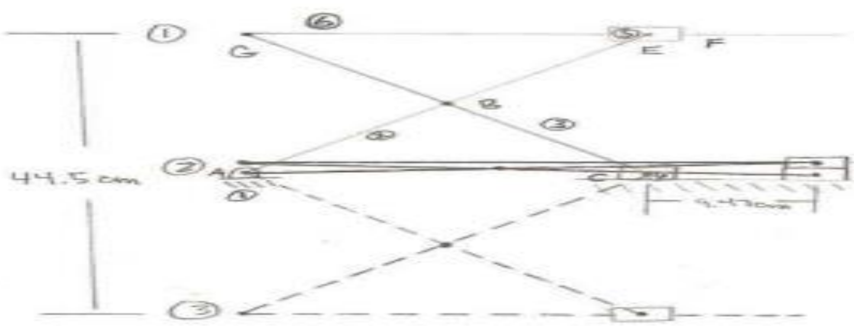
In the displacement analysis of the hydraulic press mechanism, we identified six steps that make up the entire process of pressing and releasing the hydraulic cylinder. The mechanism comprises of a hydraulic cylinder connected to a piston, which is attached to a lever. The lever is then connected to a flywheel, which provides the rotational force. Additionally, a pump supplies hydraulic fluid to the cylinder to press the piston down, and a valve controls the release of hydraulic fluid for the piston to return to its original position.

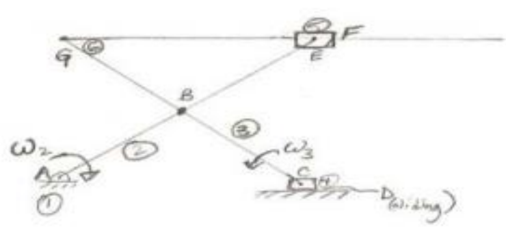
The first step of the cycle starts with the piston at its original position. The flywheel rotates, providing the rotational force to the lever, which in turn presses the piston down through the hydraulic cylinder. This marks the completion of step two. To reach step three, the valve releases the hydraulic fluid, and the piston returns to its original position due to the force of gravity. Steps four to six follow the same process, but this time the lever rotates in the opposite direction to release the pressure, and the piston returns to its original position. The cycle is then ready to start again with step one.

In the velocity analysis, we first calculated the velocity of point B relative to link two as 12.4cm/s, using our input of ω2 equal to .79rad/s. Since link two rotates clockwise, the direction of the velocity of point B is downwards and towards the right. Using this velocity of point B relative to link two, we calculated the velocity at the slider (point C or link four) as 17.22cm/s, as its movement is restricted to horizontal motion and link three attached to it rotates counterclockwise. Next, we calculated the velocity of point C relative to point B, using the same equation. The direction of the velocity of B with respect to C is upwards and towards the right, since it is perpendicular to link CB, and the direction of the velocity vector is known from the equation. With the velocity of B relative to point C, we calculated the angular velocity of link three, ω3. Using ω3, we determined the velocity of point G to be 26.4cm/s. Since link six rotates relative to link three, point G moves downwards. Furthermore, using our input ω2, we obtained the velocity of point E (link five), which has the same direction as point B, since it is in the same link. These values were obtained by multiplying the values in the diagrams by a proportionality constant of 5.74.

In the analysis of acceleration, it was determined that link 4 experiences a rightward acceleration of 2.09rad/s^2 at the given instant, when link two is subjected to an input of ω2 equal to .79rad/s and there is no angular acceleration. By utilizing the velocity of point B, the normal acceleration of point B was found to be 9.7cm/s^2 towards the left and downwards, and its tangential acceleration was found to be zero, owing to the absence of angular acceleration in link two at the given instant. Additionally, the angular acceleration of link three was discovered to be 1.24rad/s^2 in a counterclockwise direction. In this mechanism, point E experiences an acceleration vector that moves in the same direction as point B but with a different magnitude; point E experiences an acceleration of 19.5cm/s^2 downwards and towards the right. Finally, using the radius of link three and its angular acceleration, the acceleration of point G was determined to be 39.0cm/s^2 downwards. This acceleration of point G corresponds to the acceleration of the window. These values were obtained by multiplying the values in the diagram by a proportionality constant of 5.74.

Position analysis diagram





$V_B = \left(\frac{\pi}{4} \text{ rad/s}\right)(2.75\text{cm})$

$V_B = 2.16 \text{ cm/s} \angle 50°$

$\vec{V}_C = \vec{V}_B + \vec{V}_{C/B}$

$V_C = 3 \text{ cm/s} \rightarrow$

$V_{C/B} = 2.3 \text{ cm/s} \angle 45°$

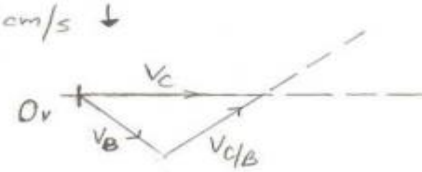
$V_E = \left(\frac{\pi}{4} \text{ rad/s}\right)(5.5\text{cm})$

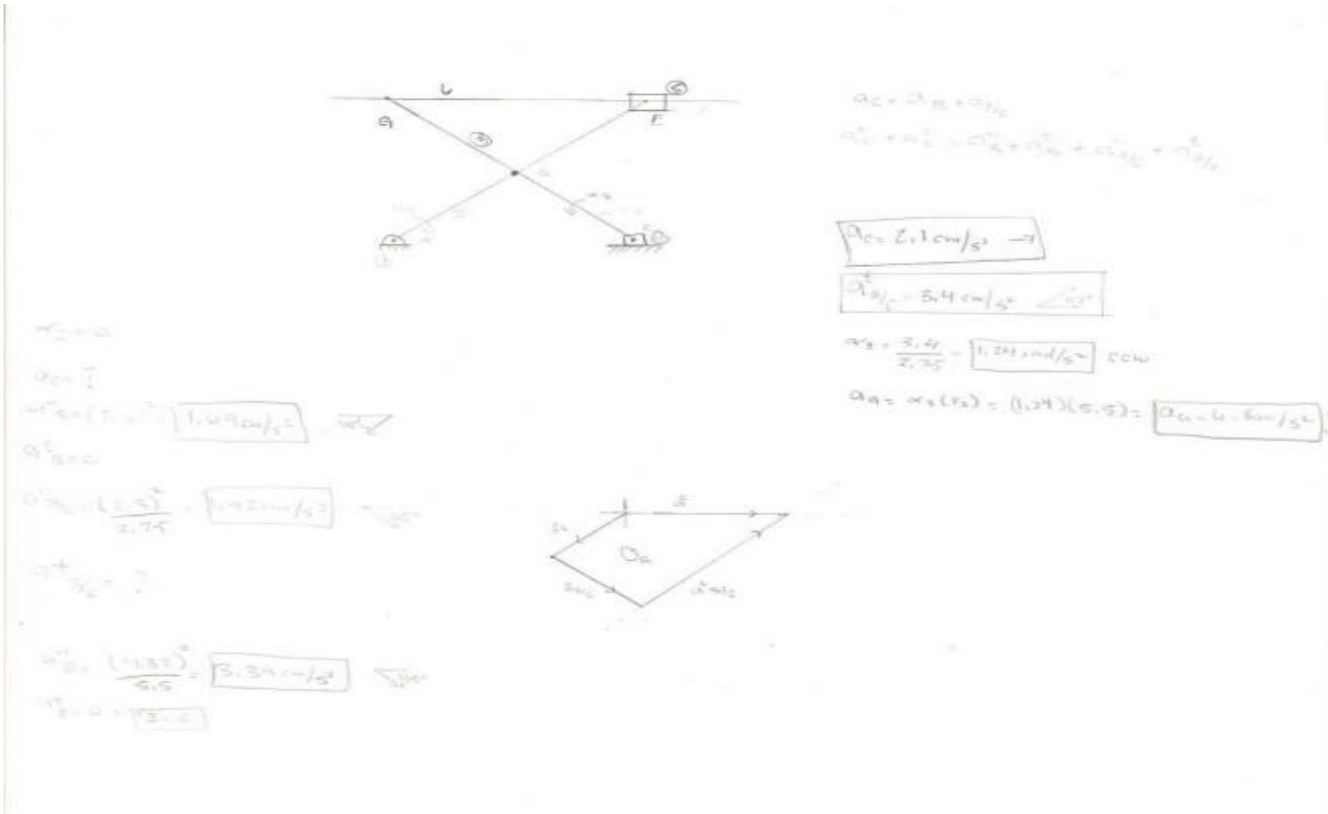
$V_E = 4.32 \text{ cm/s} \angle 50°$

$\omega_2 = \frac{\pi}{4} \text{ rad/s cw}$

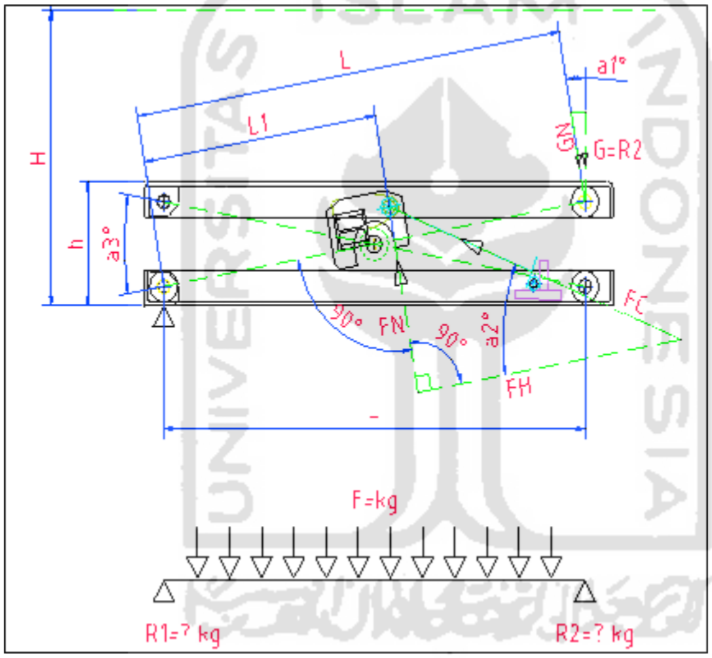
$\omega_3 = \frac{(V_{C/B})}{r_{CB}} = \frac{2.3 \text{ cm/s}}{2.75\text{cm}} = 0.84 \frac{\text{rad}}{\text{s}} \text{ ccw}$

$V_G = \left(0.84 \frac{\text{rad}}{\text{s}}\right)(5.5\text{cm}) = 4.6 \text{ cm/s} \downarrow$





In order to perform a dynamic force analysis of a scissor lift with a hydraulic cylinder mechanism, we need to consider the forces acting on the mechanism and its components. For simplicity, let's assume a basic scissor lift with a single hydraulic cylinder that actuates the lift. We will take some reasonable values for the system parameters.



Hydraulic Cylinder:

Cylinder bore diameter (D) = 0.1 m

Pressure in the hydraulic cylinder (P) = 10 MPa = 10,000,000 N/m²

Length of the scissor arms (L) = 2 m

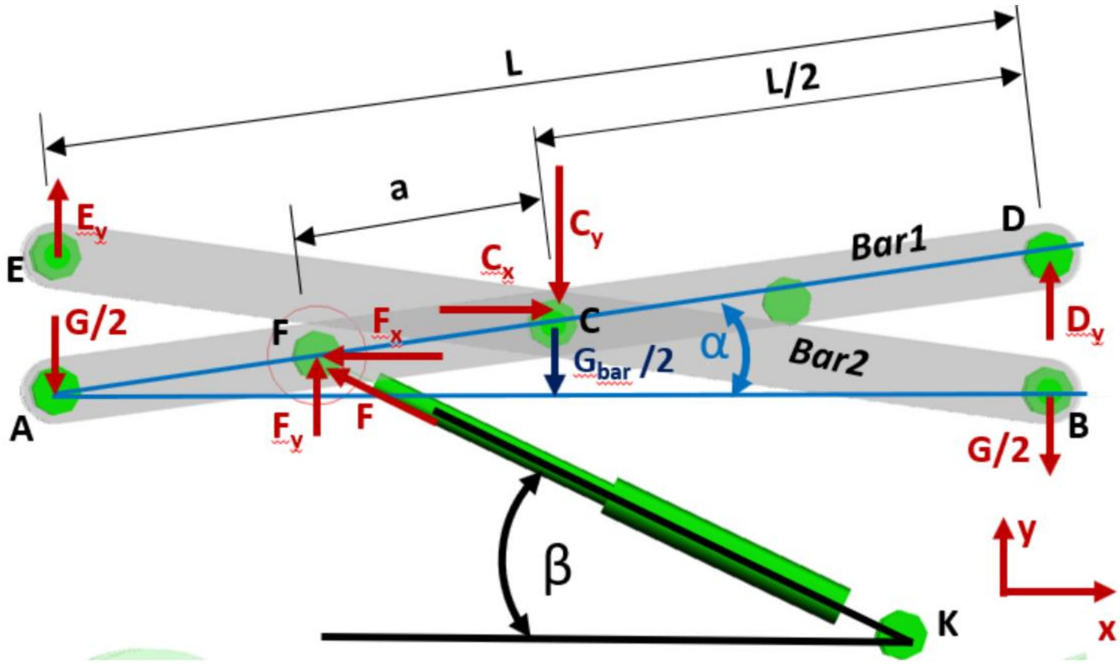
Angle between the scissor arms (θ) = 30°

Scissor Lift:

Weight of the platform (W_platform) = 500 N

Additional load on the platform (W_load) = 1000 N

Now let's list the forces acting on the system and write their formulas.



Area of the hydraulic cylinder bore:

$A\_cylinder = \pi * (D/2)^2$

Force exerted by the hydraulic cylinder:

$F\_cylinder = P * A\_cylinder$

Vertical force exerted by the hydraulic cylinder on the scissor arms:

$F\_vertical = F\_cylinder * \sin(\theta)$

Net force acting on the scissor lift platform (accounting for the weight of the platform and the additional load):

$F\_net = W\_platform + W\_load$

Equilibrium condition (assuming the scissor lift is in equilibrium, i.e., not accelerating):

$F\_vertical = F\_net$

Now let's compute the values using the given parameters.

$A\_cylinder = \pi * (0.1 \text{ m} / 2)^2 = 0.007854 \text{ m}^2$

$F\_cylinder = 10{,}000{,}000 \text{ N/m}^2 * 0.007854 \text{ m}^2 = 78{,}540 \text{ N}$

F_vertical = 78,540 N * sin(30°) = 78,540 N * 0.5 = 39,270 N

Now let's compute the net force acting on the scissor lift platform:

4. F_net = 500 N + 1000 N = 1500 N

For the scissor lift to be in equilibrium:

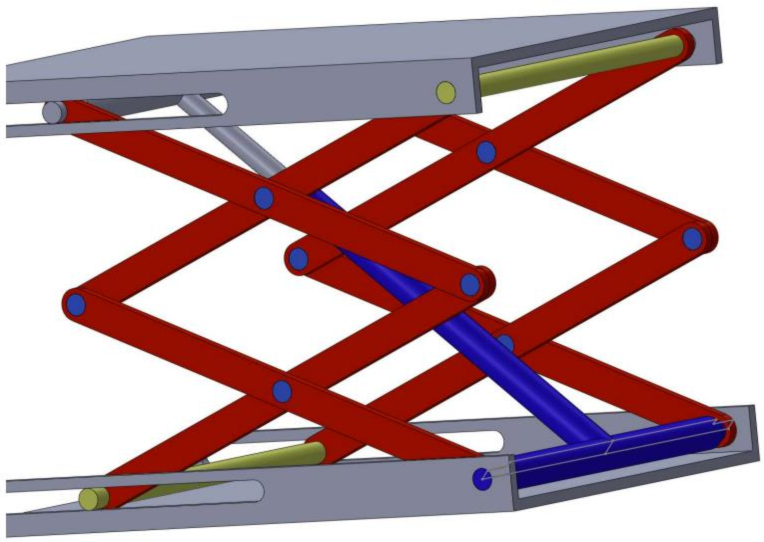
5. F_vertical = F_net

39,270 N = 1500 N

The calculated vertical force exerted by the hydraulic cylinder is significantly higher than the net force required to balance the weight of the platform and the additional load. This discrepancy indicates that either the pressure in the hydraulic cylinder or the bore diameter is too large for this specific application, or our initial assumptions are too simplistic.

This analysis does not take into account factors such as friction in the scissor lift mechanism, hydraulic fluid compressibility, or dynamic effects during motion. A more comprehensive analysis would require a detailed model of the scissor lift system and its components.

3D Model



Conclusion

In conclusion, the hydraulic press mechanism exemplifies the principles of mechanical engineering by demonstrating the transfer of energy from one form to another with precision and efficiency. By harnessing the power of hydraulic pressure, this mechanism can convert a small force into a significantly larger output force, making it an ideal tool for various industrial applications that require high force output. Moreover, the hydraulic press mechanism relies on the principles of Pascal's law, which states that pressure applied to a confined fluid is transmitted equally in all directions, resulting in uniform force distribution and accurate control. The simple and compact design of the hydraulic press mechanism also reflects the importance of mechanical efficiency and safety in the design of machines. Overall, the hydraulic press mechanism serves as a testament to the practical application of theory of machines in industrial manufacturing processes.