



Robotic Arm Design



FOR LIFTING BOXES IN INDUSTRIES

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Essential Question

“How can we, as a team, apply trigonometric principles to design and build a robotic arm that helps solve a specific problem in our community?”

Agenda

➔ Introduction

Overview of robotic arms
Problem statement
Purpose of robotic arms

➔ Math Body

Mathematical analysis
Design process

➔ Conclusion

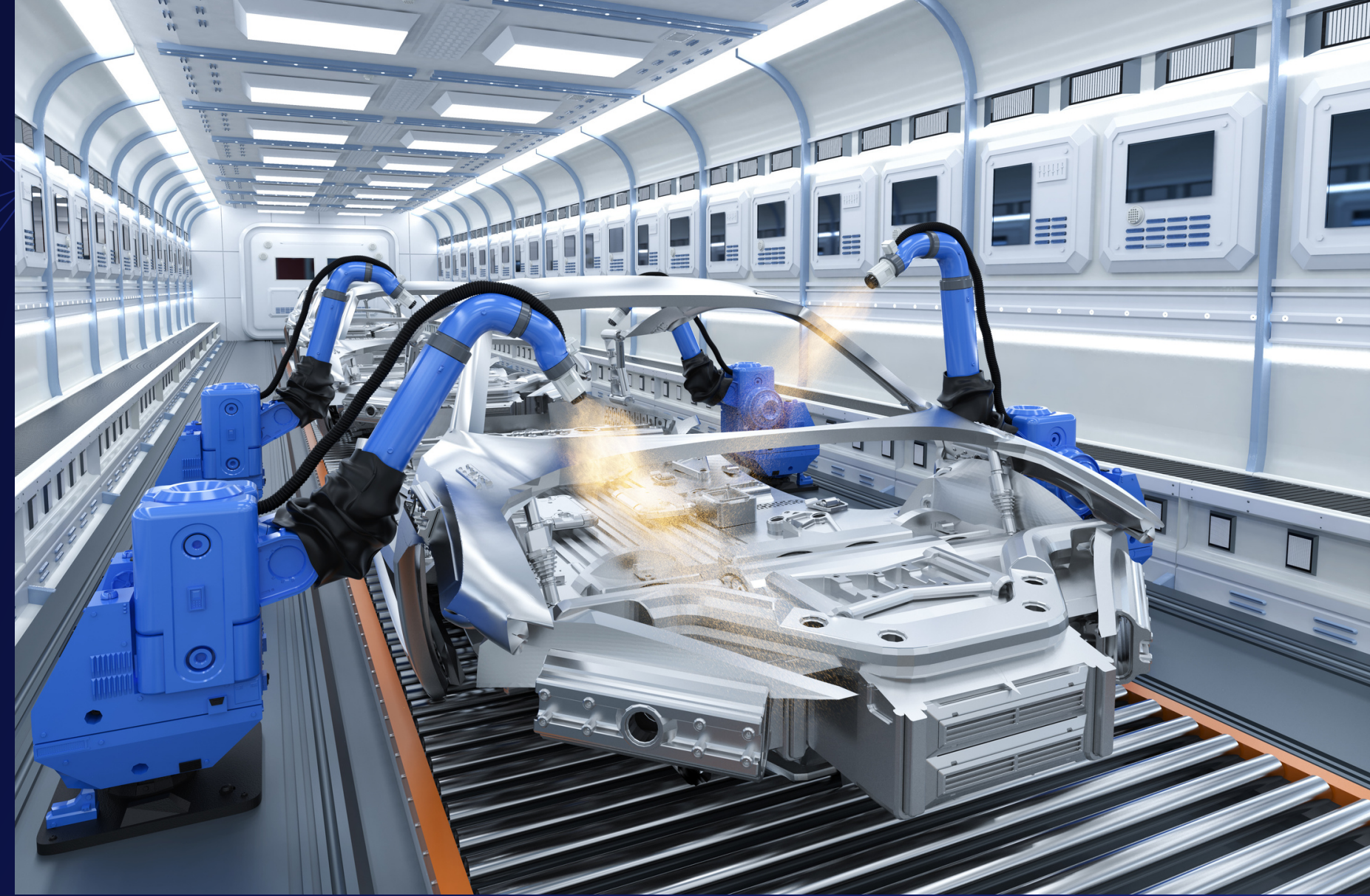
Results and conclusion





Introduction

- Many factories today rely on robotic arms to complete tasks efficiently
- Some factories can produce products extremely fast using automation
- For example, BMW's factory in Mexico can produce a car in only 48 hours
- Robotic arms reduce human labor and increase productivity
- They are designed to lift heavy objects safely and accurately





Problem of the Task

- Factory workers are required to lift heavy boxes repeatedly
- This increases the risk of injuries and fatigue
- Humans cannot work continuously without rest
- A safer and more efficient solution is needed





Why Robotic Arms?



- Can lift heavy objects safely
- Reduce workplace injuries
- Increase speed and productivity
- Work continuously without fatigue
- Improve accuracy in factories



Process

01

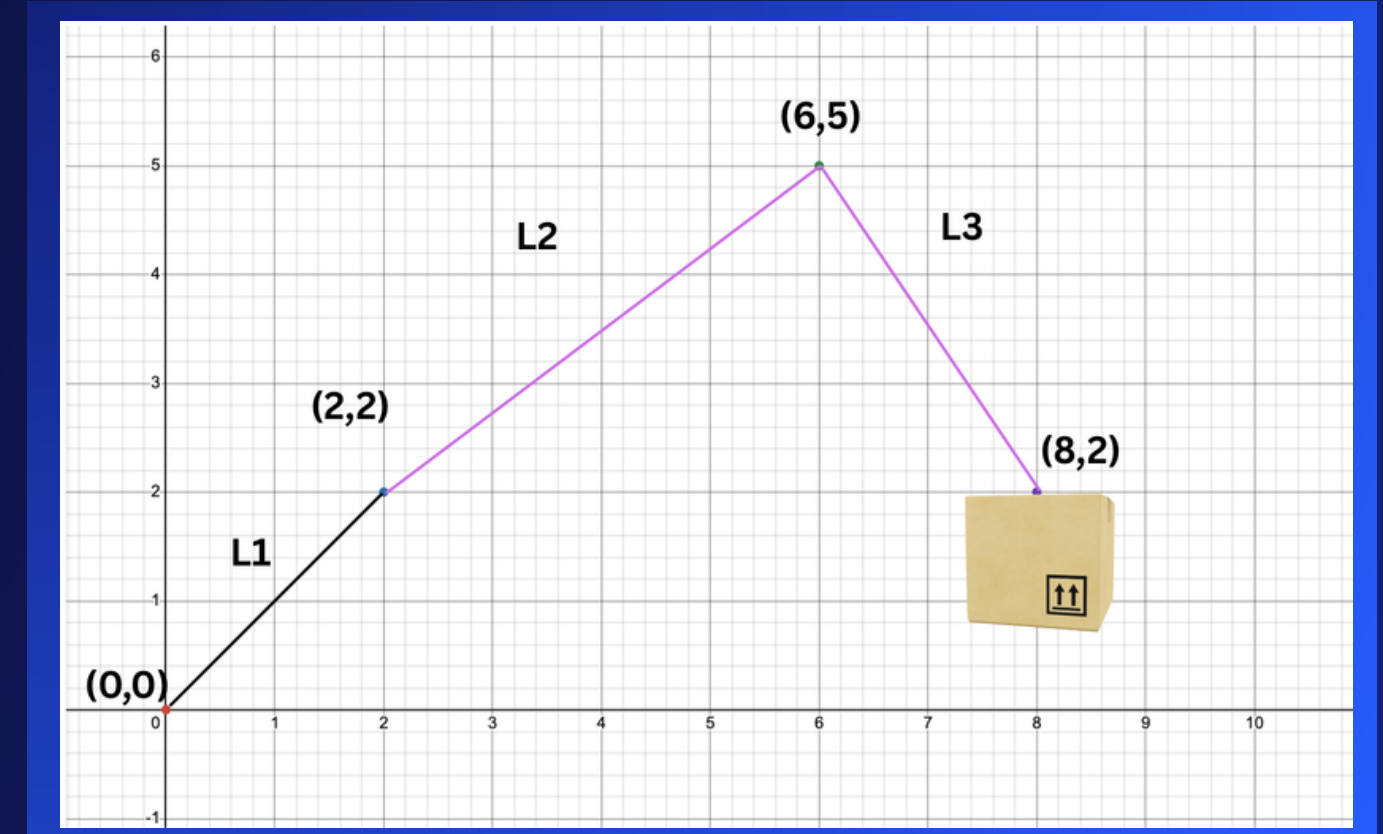
Identify the problem in factories where workers must lift heavy boxes repeatedly, which can cause injuries and slow productivity.

01

Design the robotic arm using a coordinate plane and divide it into segments (L1, L2, L3) to model its movement.

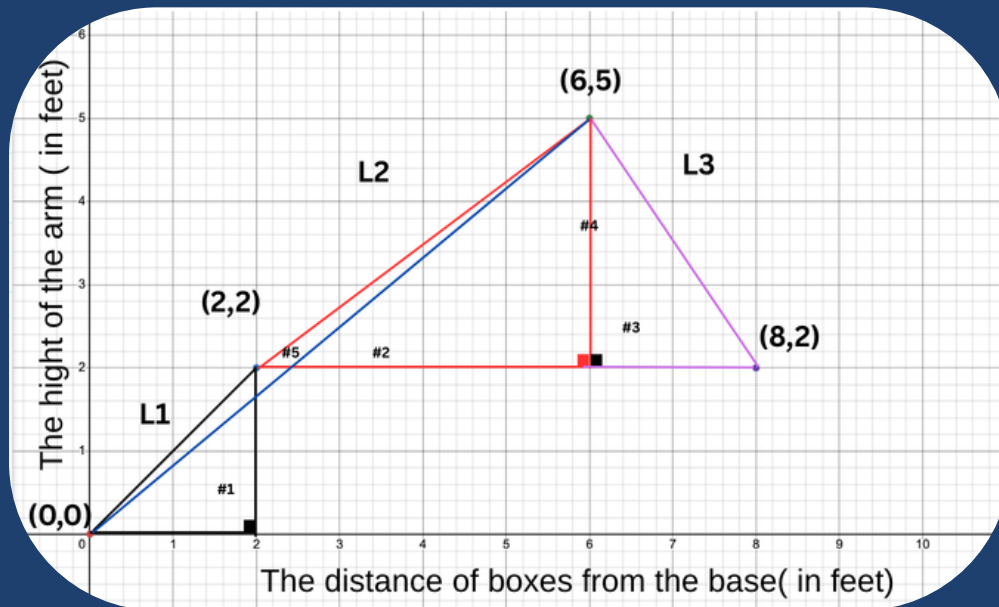
01

Apply trigonometric formulas to calculate angles and lengths, ensuring the arm can lift boxes safely and accurately.

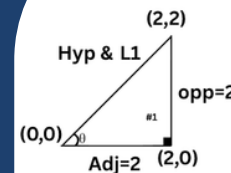




Math analysis



Triangle 1



Pythagorean theorem

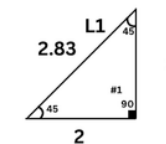
$$\begin{aligned} a^2 + b^2 &= c^2 \\ 2^2 + 2^2 &= c^2 \\ 4 + 4 &= c^2 \\ \sqrt{c} &= \sqrt{8} \\ c &= 2.83 \end{aligned}$$

SOH CAH TOA

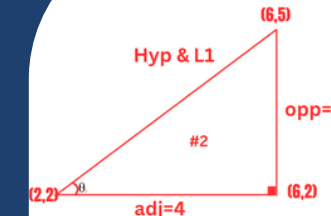
$$\begin{aligned} \sin &= \frac{\text{Opposite}}{\text{Hypothenes}} \\ \sin \theta &= \frac{2}{2.83} = \\ \sin^{-1} \left(\frac{2}{2.83} \right) &= 45^\circ \end{aligned}$$

Now we already define the theta and we know that we have a right triangle so we know it's a 90 degree, and to know the last angel we will subtracr 90 and 45 from 180

$$180 - 90 - 45 = 45$$



Triangle 2



Distance formula

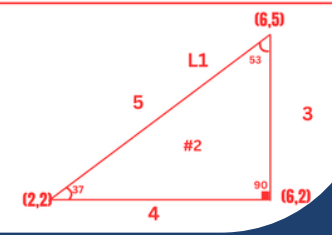
$$\begin{aligned} d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ d &= \sqrt{(6 - 2)^2 + (5 - 2)^2} \\ d &= \sqrt{(4)^2 + (3)^2} \\ d &= \sqrt{16 + 9} \\ d &= \sqrt{25} \\ d &= 5 \end{aligned}$$

SOH CAH TOA

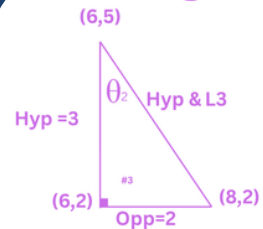
$$\begin{aligned} \sin &= \frac{\text{Opposite}}{\text{Hypothenes}} \\ \sin \theta &= \frac{3}{5} = \\ \sin^{-1} \left(\frac{3}{5} \right) &= 37^\circ \end{aligned}$$

Now that we have defined theta 1 and we know this is a right triangle we can determine the last angle. Subtract 90° and 37° from 180°:

$$180 - 90 - 37 = 52$$



Triangle 3



Pythagorean theorem

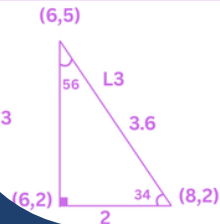
$$\begin{aligned} a^2 + b^2 &= c^2 \\ 2^2 + 2^2 &= c^2 \\ 4 + 4 &= c^2 \\ \sqrt{c} &= \sqrt{8} \\ c &= 3.6 \end{aligned}$$

SOH CAH TOA

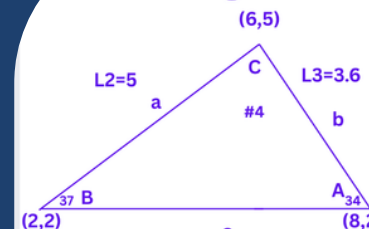
$$\begin{aligned} \cos &= \frac{\text{Adjecnt}}{\text{Hypothenes}} \\ \cos \theta &= \frac{2}{3.6} = \\ \cos^{-1} \left(\frac{2}{3.6} \right) &= 56^\circ \end{aligned}$$

Now that we have defined theta 1 and we know this is a right triangle we can determine the last angle. Subtract 90° and 56° from 180°:

$$180 - 90 - 56 = 34$$



Triangle 4



You get Triangle 4 by joining the points from Triangle 2 and Triangle 3, so it uses the same side lengths and angles

from the previu triangles we know the value of L2=5 and L3=3.6

Also we know the values of the Angles:

$$A = 34 \text{ and } B = 37$$

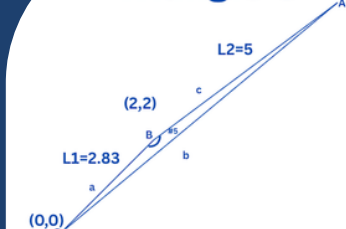
and to know the value of angle C we will subtract 34 and 56 from the total Measure of the triangle

$$C = 180 - 34 - 37 = 109$$

Distance formula

$$\begin{aligned} d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ d &= \sqrt{(8 - 2)^2 + (2 - 2)^2} \\ d &= \sqrt{(6)^2} \\ d &= \sqrt{36} \\ d &= 6 \end{aligned}$$

Triangle 5



Distance formula

$$\begin{aligned} d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ d &= \sqrt{(6 - 0)^2 + (5 - 0)^2} \\ d &= \sqrt{36 + 25} \\ d &= \sqrt{61} \\ d &= 7.81 \end{aligned}$$

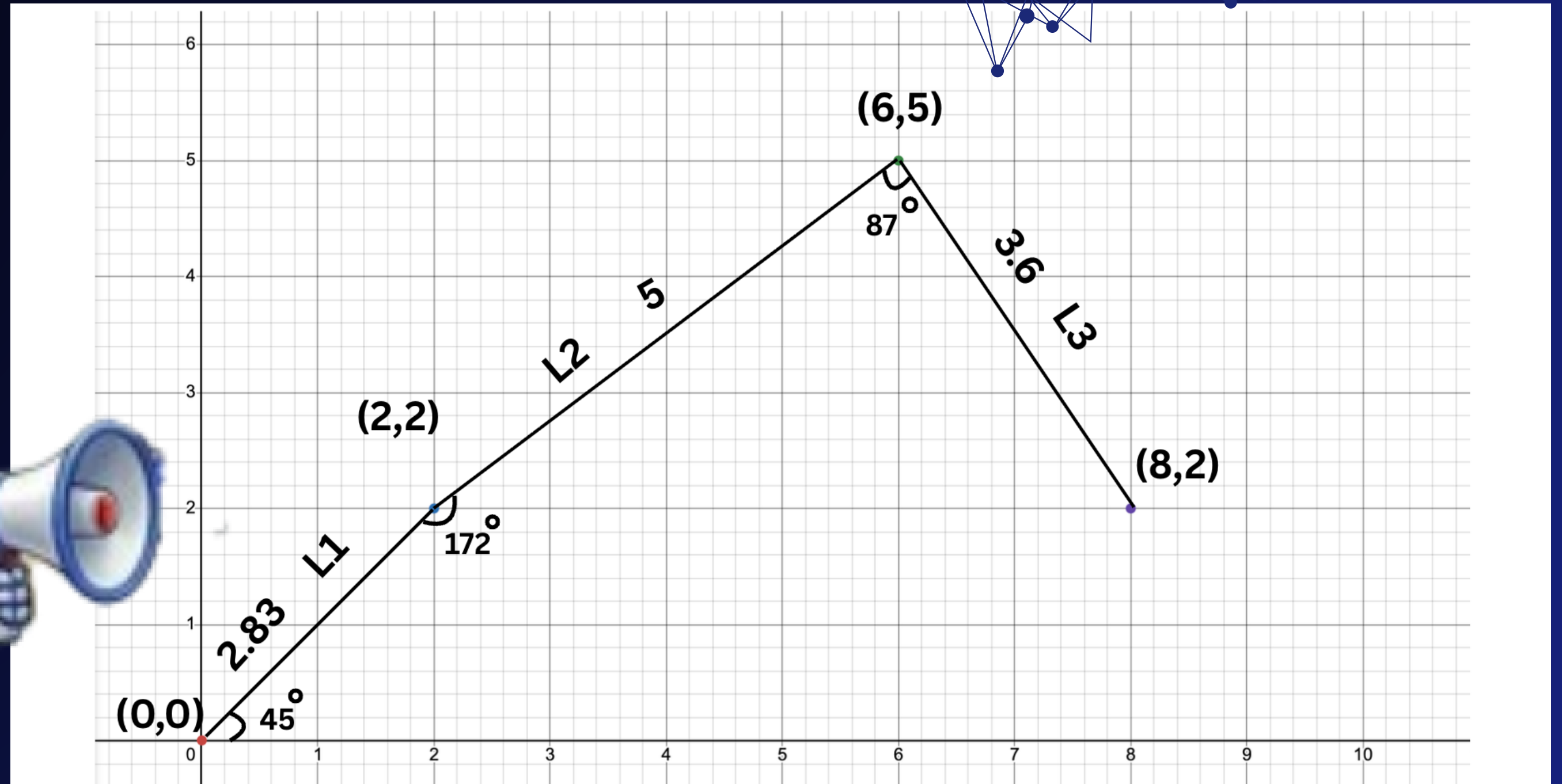
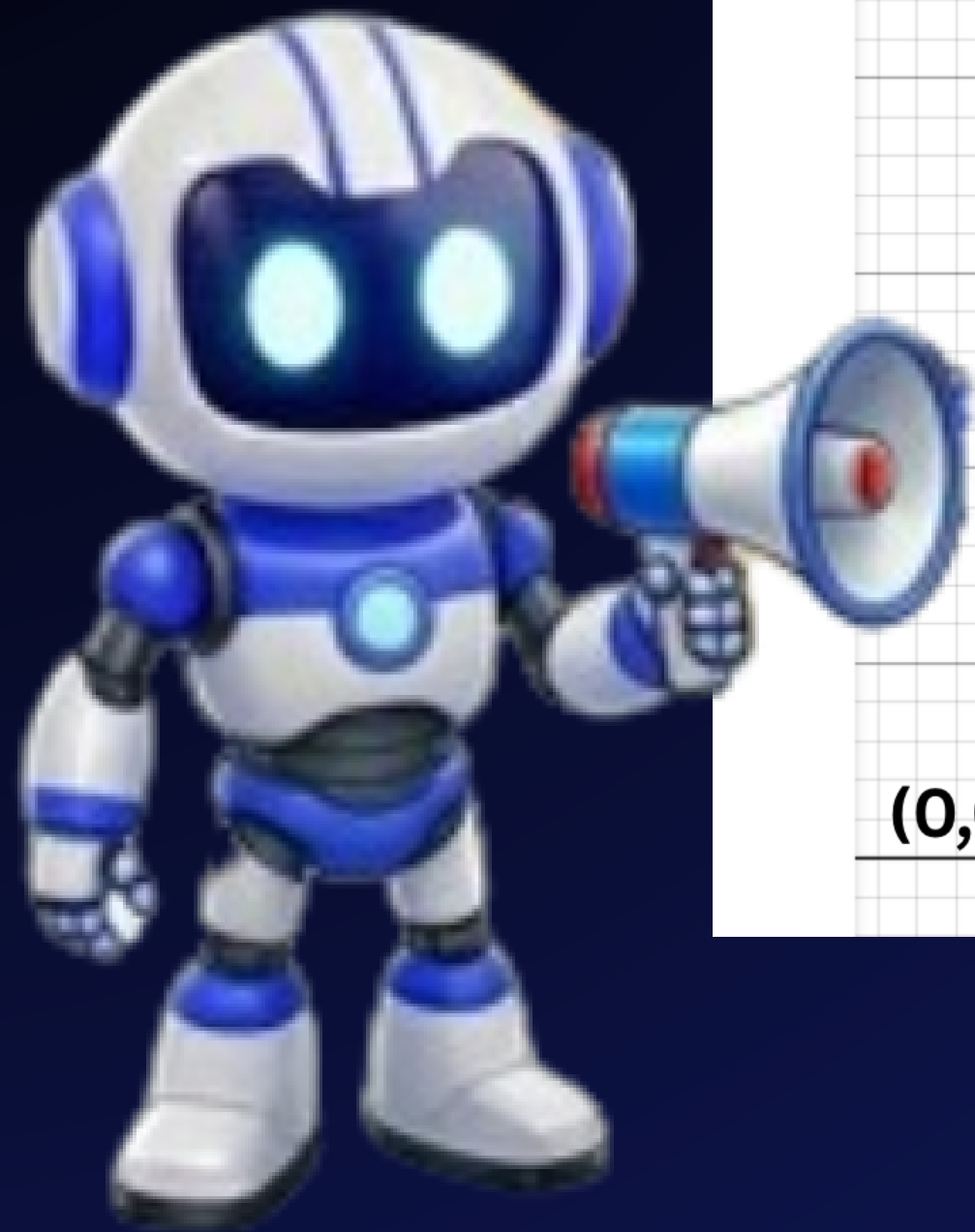
Law of Cosine to find an angel

$$\begin{aligned} \cos(B) &= \frac{a^2 + c^2 - b^2}{2ac} \\ \cos(B) &= \frac{(2.83)^2 + 5^2 - 7.81^2}{2(2.83)(5)} \\ \cos(B) &= 171.87 = 172 \end{aligned}$$

Law of sin

$$\begin{aligned} \frac{a}{\sin(A)} &= \frac{b}{\sin(B)} = \frac{c}{\sin(C)} \\ \frac{2.83}{\sin(34)} &= \frac{7.81}{\sin(37)} = \frac{2.83}{\sin(172)} \times \frac{7.81}{\sin(172)} \text{ cross multiply} \\ 7.81 \cdot \sin(34) &= \sin(172) \cdot 2.83 \\ \frac{7.81 \cdot \sin(34)}{\sin(172)} &= \frac{\sin(172) \cdot 2.83}{\sin(172)} \\ \sin(a) &= \sin(172) \cdot \frac{2.83}{7.81} = 0.05 = \sin^{-1}(0.05) = 2.9 \text{ the a value} \\ C &= 180 - 2.9 - 172 = 5.2 \end{aligned}$$

Results





Conclusion

- Trigonometry helps robotic arms move safely and precisely
- This project connects math to real-world engineering applications
- Mistakes with formulas helped me improve my problem-solving skills
- The project prepared me for future studies in computer science and engineering





Thank You
For Your Attention