

Design Flexibility

Lego pieces are easily assembled and disassembled, allowing for rapid prototyping and iteration. These features make it an excellent tool for engineering and programming in a hands-on, engaging way.

The lego ev3 are designed to bring your creations to life with precise and powerful movements. Each motor in the ev3 system has its own unique specifications that make it suitable for different applications in our competition.

Large Motor:

The ev3 large motor is known for its strength and precision. And here are its key specifications:

- Rotation speed: the large motor operates at a speed of 160-170 RPM
- Torque: it has a running torque of 20 N/cm (approximately 30 oz/in) and a stall torque of 40 N/cm (approximately 30 oz/in). this means it can handle significant loads, making it ideal for tasks requiring more power.
- Tacho feedback: the motor includes a built-in rotation sensor that provides tacho feedback to one degree of accuracy. This feature allows for precise control of the motor's position and speed, which is crucial for tasks that require exact movements.
- Auto-ID: the motor is automatically identified by the ev3 software, simplifying the programming process.
- We connected two large motor in one axel which is connected to a series of gears with a ratio of 40/24
- This series of gears is connected to a differential connected to two wheels.

Medium Motor:

The ev3 medium motor is designed for speed and agility. Here are its key specifications:

- Rotation Speed: the medium motor runs at higher speed of 240-250 RPM. This makes it suitable for applications where quick movements are necessary.
- Torque: it has a running torque of 8 N/cm and a stall torque of 12 N/cm. while it is less powerful than the large motor, its higher speed makes it ideal for tasks that require rapid, less force movements.
- Tacho Feedback: like the large motor, the medium motor also includes a built-in rotation sensor with tacho feedback to one degree of accuracy.
- Auto-ID: This motor is also automatically identified by the ev3 software.

Both motors can be used in a variety of robotics applications, from simple machines to complex robots. The precise control offered by the tacho feedback makes them suitable for tasks that require accurate positioning, such as robotic arms or automated vehicles. The Auto-ID feature simplifies the programming process, allowing users to focus more on the design and functionality of their robots rather than the technical details of motor control.

Ackerman Steering

Ackerman steering geometry is a fundamental principle in vehicle design, particularly beneficial for automated cars. This steering mechanism ensures that all wheels follow the correct path during a turn, which is crucial for maintaining control and reducing tire wear, and here are some advantages of Ackerman steering for automated cars:

- **Improved Maneuverability:** one of the primary benefits of Ackerman steering is its ability to improve the maneuverability of a vehicle. By allowing the wheels to turn at different angles, it ensures that each wheel follows its optimal path during a turn. This is particularly useful for automated cars, which need to navigate tight corners and complex routes with precision. Enhanced maneuverability makes it easier for these vehicles to operate in urban environments where space is limited.
- **Increased Driving Stability:** Ackerman steering also contributes to increased driving stability. By ensuring that the wheels are correctly aligned during turns, it reduces the likelihood of skidding or slipping, which can be particularly dangerous at high speeds. For automated cars, which rely on precise control systems to maintain safety, this added stability is crucial. It helps the vehicle maintain its intended path, even in challenging driving conditions.
- **Reduced Tire Wear:** Another significant advantage of Ackerman steering is the reduction in tire wear. When wheels are not aligned correctly during a turn, they can scrub against the road surface, leading to increased wear and tear. Ackerman steering minimizes this issue by ensuring that each wheel follows the correct path, thereby extending the lifespan of the tires. This is not only cost-effective but also enhances the overall efficiency of the vehicle.
- **Enhanced Steering Control:** Ackerman steering provides enhanced steering control, making the vehicle more responsive to inputs. For automated cars, which rely on precise steering mechanism to navigate, this improved control is essential. It allows the vehicle to make smooth

- and accurate turns, which is critical for maintaining safety and comfort for passengers. The precise control also helps in executing complex maneuvers, such as parallel parking or navigating through narrow streets.
- **Simplified Wheel Alignment:** the Ackerman steering mechanism simplifies the process of wheel alignment. Proper wheel alignment is crucial for the optimal performance of any vehicle, and automated cars are no exception. Simplified alignment processes mean that maintenance tasks can be performed more quickly and efficiently, reducing downtime and ensuring that the vehicle remains in top condition.
 - **Better Handling of Low-Speed Maneuvers:** Automated cars often need to perform low-speed maneuvers, such as parking or navigating through traffic. Ackerman steering is particularly effective in these situations, as it allows for precise control of the vehicle's direction. This makes it easier for the car to handle tight turns and complex driving scenarios, enhancing the overall user experience.

EV3 MicroPython App

The ev3 micropython app is a powerful tool for programming lego Mindstorms ev3 robots using the micropython language. This app offers several advantages that make it an excellent choice for both beginners and advanced users in the field of robotics.

- **Ease of Use:** one of the primary advantages of the ev3 micropython app is its ease of use. The app provides a straightforward setup process, allowing users to quickly get started with programming their ev3 robots. By simply downloading the ev3 micropython image onto a microSD card and inserting it into the ev3 brick, users can begin coding almost immediately. This simplicity is particularly beneficial for educators and students, as it reduces the time required to set up and start learning.
- **Powerful Programming Language:** micropython is a powerful and versatile programming language that is well-suited for robotics applications. It is a subset of Python, one of the most popular programming languages in the world, known for its readability and ease of learning. Using micropython, users can write complex programs with relatively simple code, making it accessible for beginners while still being powerful enough for advanced users. This versatility allows for a wide range of applications, from simple tasks to complex robotics behaviors.
- **Enhanced Performance:** the ev3 micropython app enhances the performance of ev3 robots by leveraging the efficiency of micropython.

Programs written in micropython tend to run faster and more efficiently compared to those written in the standard ev3 programming environment. This improved performance is crucial for applications that require real-time processing and quick responses, such as obstacle avoidance or line-following robots.

- **Extensive Documentation and Support:** Another significant advantage of the ev3 micropython app is the extensive documentation and support available to users. The app comes with comprehensive guides and tutorials that help users get started and troubleshoot any issues they may encounter. Additionally, there is a large and active community of ev3 micropython users who share their experiences, code snippets, and solutions to common problems. This support network is invaluable for both beginners and experienced users looking to expand their knowledge and capabilities.
- **Flexibility and Customization:** The ev3 micropython app offers a high degree of flexibility and customization. Users can create and manage their programs using the Visual Studio Code editor, which provides a robust development environment with features like syntax highlighting, code completion, and debugging tools. This flexibility allows users to tailor their programming environment to their specific needs and preferences, enhancing their overall experience and productivity.
- **Educational Benefits:** For educators, the ev3 micropython app provides significant educational benefits. By introducing students to micropython, educators can teach fundamental programming concepts and problem-solving skills in a hands-on and engaging way. The app's integration with the ev3 robotics platform allows students to see the immediate results of their code, reinforcing their learning and making abstract concepts more concrete. This practical approach to learning helps to foster a deeper understanding of programming and robotics.

Using lego ev3 parts can significantly help reduce a robot's weight due to several key factors:

- **Lightweight Materials:** lego ev3 components are primarily made from plastic, which is much lighter than metal or other traditional materials used in robotics. This makes the overall structure of the robot lighter without compromising on strength and durability.
- **Modular Design:** the modular nature of lego ev3 parts allows for precise construction. You can build exactly what you need without adding unnecessary components, which helps in keeping the weight down.

- **Efficient Use of Space:** lego ev3 parts are designed to fit together efficiently, allowing for compact designs. This efficient use of space means fewer parts are needed to achieve the same functionality, further reducing weight.
- **Versatile Components:** many lego ev3 parts serve multiple functions, reducing the need for additional parts. For example, beams and connectors can be used in various configurations, minimizing the number of unique parts required.
- **Optimized for Education:** lego ev3 is designed with educational purposes in mind, meaning the parts are optimized for ease of use and efficiency. This often translates to lighter more streamlined designs that are easier to build and modify.

By leveraging these advantages, you can create a robot that is not only lighter but also more efficient and easier to manage.

Calculating the torque required for an Ackerman steering system involves understanding the forces at play and the geometry of the steering mechanism.

Understanding Ackerman Steering Geometry: Ackerman steering geometry ensures that all wheels of a vehicle follow concentric circles when turning, minimizing tire slip. This is achieved by angling the front wheels differently: the inside wheel turns at a sharper angle than the outside wheel.

Our medium motor torque which is controlling the Ackerman steering has a running torque of 8 N/cm and is connected to a series of gears to control the steering, that would make our equation of calculating the whole torque of the Ackerman as the following:

$$T = \text{torque of motor} * \text{ratio of bigger gear to the smaller gear}$$

$$T = 8 * 10^{-2} * 40/8$$

$$T = 40 * 10^{-2} \text{ (N/m)}$$

Pixy 1 Camera

The pixy 1 camera, also known as the CMUcam5. It is designed to simplify the integration of vision capabilities into robotics projects, making it an ideal tool for young engineers and hobbyists.

Pixy 1 features:

- Object Detection and Tracking: pixy 1 can detect and track objects based on their color signatures. Users can teach pixy to recognize objects by pressing a button, making it user-friendly and accessible even for beginners.
- High-Speed Processing: the camera processes image at 50 frames per second, allowing for real-time object tracking and quick responses in dynamic environments.
- Multiple Interfaces: Pixy 1 supports various communication interfaces, including SPI, I²C, UART, and USB, making it compatible with a wide range of microcontrollers and single-board computers like Arduino and Raspberry Pi.
- Open-Source Software and Hardware: the camera's software, firmware, and hardware are open-source, providing users with the flexibility to customize and extend its capabilities.

The pixy 1 camera can be particularly beneficial for participants in this category, which focuses on advanced robotics challenges.

- Enhanced Vision Capabilities: vision is a critical component in many robotics applications, from navigation to object manipulation. Pixy 1's ability to detect and track objects in real-time can significantly enhance the functionality of robots designed by the team. For example, robots can use pixy 1 to identify and sort objects based on color (red and green obstacles), navigate through complex environments, or interact with specific targets.
- Simplified Integration: the ease of integrating Pixy 1 with popular microcontrollers and single-board computers means that participants can quickly add vision capabilities to their projects without needing extensive knowledge of image processing. This allows them to focus on higher-level problem-solving and innovation.
- Learning and Experimentation: the open-source nature of Pixy 1 encourages learning and experimentation. Participants can delve into the camera's software and hardware to understand how it works, modify its functionality, and even contribute to its development. This hands-on experience is invaluable for developing a deep understanding of robotics and vision systems.

Sensors Used:

- Gyro Sensor: the gyro sensor measures the robot's rotational motion and orientation. It can detect changes in angle and rotational speed, providing

precise control over the robot's movements. This sensor is particularly useful for tasks that require accurate turning, maintaining balance, and navigating complex paths.

- Ultrasonic Sensor: the ultrasonic sensor measures the distance to an object using sound waves similar to how bats navigate. It can detect objects up to 250 cm away with an accuracy of ± 1 cm. This sensor is ideal for obstacle avoidance, distance measurement, and creating robots that can interact with their environment by detecting nearby objects.
- RGB Color Sensor: it is capable of detecting thousands of colors by measuring the intensity of red, green, and blue light. This advanced sensor can identify subtle variations in color, making it highly versatile for complex tasks.