**Analyzing the Ability of the Robotic Arm to Lift 2 kg and the Impact of Using Gears**

**Introduction**

In this report, we will discuss whether the motors previously used in the robotic arm can lift **2 kg** instead of **1 kg**. If the motors are insufficient, we will explore the possibility of using **gears** to increase the required torque for each joint.

**Understanding Torque and Its Importance**

**🔹 Definition of Torque**

Torque is the force required to rotate an object around a specific axis, calculated using the equation:

τ=F×d\tau = F \times d

Where:

* τ\tau = Torque (N·m)
* FF = Applied force (N)
* dd = Distance from the joint to the point where the force is applied (m)

**The applied force FF** is derived from the weight of the object being lifted:

F=m×gF = m \times g

Where:

* mm = Mass (kg)
* gg = Gravitational acceleration (9.81 m/s²)

**Calculating the Required Torque for Each Joint**

**🔹 First Joint (Base Joint)**

* Weight: **2 kg**
* Applied force: F=2×9.81=19.62NF = 2 \times 9.81 = 19.62 N
* Distance: d=0.15+0.10+0.04=0.29md = 0.15 + 0.10 + 0.04 = 0.29 m
* Required torque: τ1=19.62×0.29=5.69 N⋅m\tau\_1 = 19.62 \times 0.29 = 5.69 \, N\cdot m

**🔹 Second Joint (Middle Joint)**

* Weight: **2 kg**
* Applied force: F=19.62NF = 19.62 N
* Distance: d=0.10+0.04=0.14md = 0.10 + 0.04 = 0.14 m
* Required torque: τ2=19.62×0.14=2.75 N⋅m\tau\_2 = 19.62 \times 0.14 = 2.75 \, N\cdot m

**🔹 Third Joint (Gripper Joint)**

* Weight: **2 kg**
* Applied force: F=19.62NF = 19.62 N
* Distance: d=0.04md = 0.04 m
* Required torque: τ3=19.62×0.04=0.78 N⋅m\tau\_3 = 19.62 \times 0.04 = 0.78 \, N\cdot m

**Comparison with Previously Used Motors**

If the torque provided by the previously used motors is lower than the calculated values, they will not be able to lift 2 kg, and we will need to **improve performance using gears**.

**How to Use Gears to Increase Torque**

If the motor does not provide the required torque, a **gear reduction system** can be implemented.

**🔹 Calculating the Required Gear Ratio**

The gear ratio is calculated using the equation:

Gear Ratio=τrequiredτmotorGear\ Ratio = \frac{\tau\_{required}}{\tau\_{motor}}

For example, if the motor at the first joint provides only **3 N·m**, while we need **5.69 N·m**:

Gear Ratio=5.693≈1.9Gear\ Ratio = \frac{5.69}{3} \approx 1.9

This means that we need a **gear reduction of approximately 1:2** (i.e., the motor rotates twice while the arm moves once).

**Disadvantages of Using Gears**

🔴 **Reduced speed**: Gears decrease speed when increasing torque.

🔴 **Increased mechanical complexity**: Leads to a more complex design and maintenance difficulties.

🔴 **Added weight**: Gears contribute additional weight to the arm.

🔴 **Energy loss due to friction**: Each gear introduces resistance, leading to some energy loss.

**Final Conclusion**

✅ **If the original motors provide the required torque, there is no need for gears.**

✅ **If the motors are insufficient, gears with a 1:2 or 1:3 reduction ratio can be used to increase torque.**

✅ **It is important to note that using gears reduces speed and increases mechanical complexity.**