Robot Arm Torque Calculation Report

# 1. Introduction

This report presents the torque calculations and motor selection for a robotic arm. The arm consists of three segments with the following lengths: 15 cm, 10 cm, and 4 cm. The goal is to lift a 1 kg weight, and then evaluate if the same motors can handle a 2 kg load.

# 2. Arm Dimensions

Segment lengths:

• Base to Joint 1: 15 cm

• Joint 1 to Joint 2: 10 cm

• Joint 2 to Gripper: 4 cm

# 3. Torque Calculations

Torque is calculated using the formula:  
Torque (Nm) = Force (N) × Distance from joint (m)  
Assuming g = 9.81 m/s², the force from a 1 kg mass = 9.81 N.  
  
• Joint 3 (Gripper): Torque = 9.81 N × 0.04 m = 0.392 Nm  
• Joint 2: Torque = 9.81 N × (0.10 + 0.04) m = 1.3734 Nm  
• Joint 1: Torque = 9.81 N × (0.15 + 0.10 + 0.04) m = 2.8929 Nm  
  
Recommended to add 30% safety margin:  
• Joint 3: ~0.51 Nm  
• Joint 2: ~1.79 Nm  
• Joint 1: ~3.76 Nm

# 4. Servo Motor Selection

Based on the required torque values:

• Joint 3: MG90S Micro Servo (Torque ~2.2 kg·cm ≈ 0.22 Nm) — Not enough  
• Joint 2: MG996R Servo (Torque ~11 kg·cm ≈ 1.08 Nm) — Also not enough  
• Joint 1: High-torque servo like DS3218 or industrial-grade required  
  
Suggested options (with enough margin):  
• Joint 3: MG996R Servo (1.08 Nm)  
• Joint 2: DS3218 Servo (19.5 kg·cm ≈ 1.91 Nm)  
• Joint 1: Industrial servo (≥4 Nm)  
  
Links to purchase:  
- https://www.aliexpress.com/item/1005001662495412.html  
- https://www.servocity.com/hs-7954sh-servo/

# 5. Evaluation for 2kg Load

If the robot arm is required to lift 2 kg instead of 1 kg, the required torque doubles:  
• Joint 3: ~1.02 Nm  
• Joint 2: ~3.58 Nm  
• Joint 1: ~7.52 Nm  
  
Problems:  
- Motors may overheat or fail  
- Arm may move slowly or lose precision  
  
Solutions:  
- Use stronger motors  
- Add gear ratios to reduce load on motor  
- Use counterweights to balance the load