

| Motor Name | Price | Type | Torque (kg\*cm) | Torque (N\*m) | Rotation Range | Weight (g) | Required Arm Length (in) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Tower Pro MG995 | Not available in the US for 1 pack :( | Servo | 10 | 0.98 | 360° continuous |  | 4.33 |
| [Tower Pro MG996R](https://www.amazon.com/MG996R-Digital-Waterproof-Airplane-Helicopter/dp/B0DCK462XZ/ref=sr_1_3_sspa?crid=2BVYZY7ELDI1F&dib=eyJ2IjoiMSJ9.56K-hmwefmvdA0j2nTJs7eALbaDsPYbl--24Qz7n2d03NJxPLizw5b1-AjDARmUYnerbccU-RqX-cowDM_vcBlWkJC4kBFt1q6NT1cvH6bZlDklra0HhR3PDmLBql5P4njfPKj0ho3PCzmKmRAbBFqlAnGxgWQsmNX91Ys92v4Pdxxn_sxMAbW9izL4sinvDl8VR-TC4dJZEdP4YSvWjJ5fpRIrNtRLTyE2WTuyfyPqjBhfNxIi5ifnoK-BBXWUwlDytq91Cav4WD2sbLAZi3MIjOStxNJERu4FcTen9NjY.BH5K2IJvcocgplyuqUwN1KwbGhpgYvIybFi5jV2vAxs&dib_tag=se&keywords=mg996r&qid=1728250707&sprefix=mg996r%2Caps%2C160&sr=8-3-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&psc=1) | $13 for 2 | Servo | 11 | 1.07 | 180° | 55 | 4.33 |
| Futaba S3003 |  | Servo | 3.2 | 0.31 | 180° | 37 | 1.57 |
| Savox SC-0251MG |  | Servo | 15 | 1.47 | 180° | 58 | 6.49 |
| [Hitec hs-645MG](https://www.amazon.com/Hitec-32645S-HS-645MG-Torque-Metal/dp/B003T6RSVQ/ref=sr_1_1?crid=1MMDVJDWUMYJ6&dib=eyJ2IjoiMSJ9.tat9Yj1iSkYVCCP7fkJGHtwy6YDf6TwUDh0_x9B43am11sRDZcHNWielurGrGM5iY1vTpXmQHocxpwpCPHqOtJlKKr5dIeIca5fS7xr0kHW36nLTmyWrsAkbh48151-pZQdwxZVbt3Cp4BBxRqhCb_d9a5seWuWMcXrcJQ-C0ZaREa0f0lNmEfyWnQ5HuY77A-F1ZjJknvc-LJDX7Xut06vJaRjobcZ5z4aYHYq8YMT6BnHYuZABsauzgBMl2iqRxIWvYduFHwe2cArL2hOKX7Wk3B2dQ4IhxqN0z2IbOfg.OzL8SEAFwAjscmobiephuq-JRyZBkS9zJ2q2Yw4GAJA&dib_tag=se&keywords=Hitec%2Bhs-645MG&qid=1728252927&sprefix=hitec%2Bhs-645mg%2Caps%2C153&sr=8-1&th=1) | $35 | Servo | 9.6 | 0.94 | 180° | 55 | 4.33 |
| [Feetech FS90R](https://www.amazon.com/Feetech-Continuous-Rotation-Arduino-Microbit/dp/B086ZGTLZB/ref=sr_1_5?crid=1D9K7M2UBOUTL&dib=eyJ2IjoiMSJ9.z5OKbkfv2f0DFyWkkRI6pdwzA68MYq07TjRf4Jnb08CN1UfECOHmXy2QDQ3XgvLzAD9tP6Th1s9OeuuE_Vv5ju3TnhvDmdCGh5tQwlRts52EcNP_gw0vg6z2lhVRw0nQXHTJSJ_fd74t55gqKAK-7lyAlZY4nCIvimimyba9pdiYEqhtknYXElagG864w7dGJOhtL4IsTZI6urQagNqVOeZwsYV2KwuT4njJUukWhGmuQrAskq9O1Gb43UIeZiNSlxQ3Y6za7dTdrFaTS0tX3_txo_TYqf-waBtDipQf610.J3ue5QlCKgO2m_kbJji4qEZu9agS9VFw0CtE9VoLdX0&dib_tag=se&keywords=Feetech+FS90R&qid=1728252390&sprefix=feetech+fs90r%2Caps%2C120&sr=8-5#customerReviews) | $15 for 2 | Continuous Servo | 1.5 | 0.15 | 360° continuous | 13.5 | 0.79 |
| Dynamixel AX-12A |  | Servo | 15 | 1.47 | 300° | 53.5 | 6.49 |
| StepperOnline Nema 17 |  | Stepper | 38 | 3.72 | 200 steps (1.8°/step) | 400 | 16.14 |
| Pololu 35x36mm Stepper Motor |  | Stepper | 45 | 4.41 | 200 steps (1.8°/step) | 340 | 17.72 |
| Adafruit Stepper Motor 42STH38 |  | Stepper | 26 | 2.55 | 200 steps (1.8°/step) | 280 | 11.02 |
| DFRobot 5V Stepper |  | Stepper | 1.8 | 0.18 | 64 steps (5.625°/step) | 30 | 0.79 |

### **Key Considerations:**

* **Tower Pro MG996R** is a good servo choice with reasonable torque and weight, and you would need an arm length of about **4.33 inches (12 cm)** to lift a 2-pound opponent.
  + You can directly control the Tower Pro MG996R servo motor using a PWM signal from an ESP32 without the need for an additional motor driver. The MG996R is a standard hobby servo that operates on PWM signals to control its position.
  + PWM Control: The MG996R expects a PWM signal (typically 1 ms to 2 ms pulse width) to determine its position. The ESP32 has built-in PWM capabilities that can easily generate this signal.
  + Power Supply: While you can control the servo directly with the ESP32, ensure that the servo is powered separately with an appropriate power supply. The MG996R can require a significant amount of current (up to 1.5A under load), which the ESP32 cannot provide.
  + Common Ground: Make sure to connect the ground of the ESP32 and the power supply for the servo together to ensure proper operation.
* **Savox SC-0251MG** provides a bit more torque (15 kg·cm) with only a slightly heavier weight, allowing for a longer arm of **6.49 inches (16 cm)**.
* **Nema 17 Stepper** offers very high torque (38 kg·cm) but is much heavier at 400 grams. If you opt for this, you could use a longer arm of **16.14 inches (41 cm)**.

10/14/2024

1. **High-Speed Servo with Torque Amplification**
   1. Servo: Instead of using a Tower Pro servo, you could switch to a Savox SC-1256TG or a Turnigy TGY-1501 high-torque, high-speed digital servo. These are relatively lightweight but offer more torque and faster actuation, making them better suited for rapid flips.
      1. Savox SC-1256TG (High-Speed Digital Servo)
         1. Max Stall Current: ~3.5 A at 6.0V
         2. Operating Voltage: 4.8-6.0V
         3. Torque: 20 kg/cm (277 oz/in) at 6.0V
         4. Speed: 0.15 sec/60° at 6.0V
         5. Operating Temperature: -10°C to 50°C
         6. Weight: ~60g
         7. Pros: Strong and fast for its size.
         8. Cons: Consumes significant current under load, may require a dedicated power source like a LiPo battery.
      2. Turnigy TGY-1501 (High-Torque Servo)
         1. Max Stall Current: ~2.5 A at 6.0V
         2. Operating Voltage: 4.8-6.0V
         3. Torque: 18 kg/cm (250 oz/in) at 6.0V
         4. Speed: 0.16 sec/60° at 6.0V
         5. Operating Temperature: -10°C to 60°C
         6. Weight: ~56g
         7. Pros: Affordable with decent torque and speed.
         8. Cons: Slightly slower than the Savox option but still strong.
   2. Mechanism: Pair the servo with a simple lever arm directly connected to the axle under the flipper. This eliminates the need for a pulley system, which could be causing delay due to string tension and slack.
2. **Direct Drive DC Motor with Gear Reduction**
   1. Motor: Consider a small brushless DC motor with a high reduction gear system, like a Pololu 37D with a planetary gearbox. This setup can provide significant torque while maintaining a compact design.
      1. Pololu 37D Brushless DC Motor with Gearbox
         1. Max Stall Current: 5 A at 12V
         2. Operating Voltage: 6-12V
         3. Torque: ~2.7 kg/cm (for a 19:1 gearbox at 12V)
         4. Speed: ~420 RPM at 12V (with the 19:1 gearbox)
         5. Operating Temperature: -20°C to 60°C
         6. Weight: 190g (with gearbox)
         7. Pros: High torque and speed with excellent efficiency due to brushless design.
         8. Cons: Heavier than servos and requires more complex control circuitry (ESC).
   2. Mechanism: Instead of a pulley system, directly attach the motor to the flipper using a geared linkage. This will provide faster actuation without the inefficiency of strings. You can design the linkage to ensure the full flip occurs within a short motor rotation (e.g., 90 or 180 degrees).
3. **Spring-Loaded Flipper with Motor Reset**
   1. Motor: Use a smaller motor like a Mabuchi 555 DC motor to tension a torsion spring. The motor only needs to pull the flipper down, and the spring will snap it back up.
      1. Mabuchi RS-555 DC Motor
         1. Max Stall Current: ~3-4 A at 12V
         2. Operating Voltage: 6-15V
         3. Torque: ~100 oz-in (7.2 kg-cm) depending on the gear ratio
         4. Speed: 6000 RPM at 12V (without a gearbox)
         5. Operating Temperature: -10°C to 60°C
         6. Weight: ~165g
         7. Pros: Lightweight, good torque with gear reduction, affordable.
         8. Cons: Requires gearing for high torque applications.
   2. Mechanism: The spring stores energy and provides the fast, powerful flipping action. The motor resets the flipper by compressing the spring, which is much less demanding in terms of power. This reduces the strain on the motor during flipping.
4. **Cam-Based Mechanism**
   1. Motor: Use a Pololu 20mm brushed DC motor with a cam setup to rapidly push the flipper upwards.
      1. Pololu 20mm Brushed DC Motor
         1. Max Stall Current: ~2-3 A at 12V
         2. Operating Voltage: 6-12V
         3. Torque: ~0.5 kg-cm (depends on gear ratio)
         4. Speed: ~10,000 RPM at 12V (without gearbox)
         5. Operating Temperature: -20°C to 60°C
         6. Weight: ~70g (with gearbox)
         7. Pros: Compact and lightweight with moderate torque.
         8. Cons: May require additional mechanical advantage (gears) for heavier loads.
   2. Mechanism: A rotating cam attached to the motor lifts the flipper in a swift motion. This method avoids the need for pulleys or complex string systems. You can adjust the cam design to match the needed flip height and speed.