Project Calculations

1. Rover Base & Structure

- **10cm Wheels:** 83 g x 2 = **166 g**
- **Base Plates (3D Printed PETG):**
    - Volume: 110 cm^3
    - Infill: 40%
    - Density: 1.3 gm/cm^3
    - Weight per Plate: 110*0.4*1.3 = 57.2g
    - Total (3 Plates): 57.2g x 3 = **171.6g**
- **Rods & Brackets:**
    - 15cm Threaded Rods (M5): 17.33g x 4 = 69.32g
    - Brackets: 5.724g x 2 = 11.448g
    - Subtotal (Rods & Brackets): **80.768g**

2. Rover Electronics

- **ESP 32:** 15 grams
- **L298N (Motor Driver):** 40g
- **MPU (Sensor):** 3g
- **12v 200 rpm Johnson motors :** 165 g *2 = 330 g
- **Wires:** 20g
- **Total (Wheel Electronics): 421 g**

3. Drone Components

- **F450 Frame:** 415g
- **Pixhawk (Flight Controller):** 15.5g
- **3S Lipo Battery:** 288g
- **Emax MT2213 Motors:** 53g x 4 = **212g**
- **SimonK 30A ESCs:** 3.2g x 4 = **12.8g**
- **Receiver:** 2.5g
- **PDB (PTB XT60):** 12g

4. Fasteners & Buffer

- **Bracket to Motor Screws (M3 7mm x 4):** 4g
- **Bracket to Base Plate (M3 15mm x 12 screws/bolts):** 16.8g
- **M5 Nuts (x24):** 1.36g x 24 = 32.64g
- **M5 Washers (x24):** 0.3g x 24 = 7.2g
- **Fastener Total:** 4 + 16.8 + 32.64 + 7.2 = **60.64g**
- **Buffer:** 100g
- **Net Total (Fasteners & Buffer): 160.64g**

5. Final Weight & Thrust Summary

- Full Weight Calculation:
  166 + 80.76 + 171.6 + 421 + 1235 + 160.64 = 2235 g
- **Total Weight: 2.235 kg**
- **Motor Thrust:** 860g per motor (Emax)
- **Net Thrust:** 860g x 4 = **3440g**
- **Thrust-to-Weight Ratio: 1.53**
- **Motor Size:** 2208 - 2216
- **Propeller Size:** 1045 / 945

Wheel Torque Estimation

The **main equation** for calculating the **torque required** for a self-balancing robot (to keep it upright or recover from tilt) is:

$$\boxed{\tau = mgL\sin(\theta)}$$

Where:

- τ = torque required (N·m)
- m = mass of the robot (kg)
- g = acceleration due to gravity (9.81 m/s²)
- L = distance from wheel axle to the robot's center of mass (m)
- θ = tilt angle from vertical (radians or degrees)

If you also want to include forward motion (accelerating or climbing), add the **drive torque** term:

$$\boxed{\tau = r\,(ma + mg\sin(\alpha) + C_{rr}mg\cos(\alpha))}$$

Where:

- r = wheel radius (m)
- a = desired linear acceleration (m/s²)
- α = slope angle (radians or degrees)
- C_{rr} = rolling resistance coefficient (≈0.01–0.02 for small rubber wheels)

Torques at different lean angles and wheel sizes

Wheel Ø	**15°**	**20°**	**30°**
7 cm	0.229 N·m (2.34 kg·cm)	0.293 N·m (2.98 kg·cm)	0.413 N·m (4.21 kg·cm)
10 cm	0.243 N·m (2.48 kg·cm)	0.306 N·m (3.12 kg·cm)	0.426 N·m (4.35 kg·cm)

RPM at different wheel sizes

Wheel Diameter	**Radius** **r (m)**	**Speed** **v = 1 m/s**	**Wheel RPM**
7 cm	0.035	1.0	**≈ 273 rpm**
10 cm	0.05	1.0	**≈ 191 rpm**