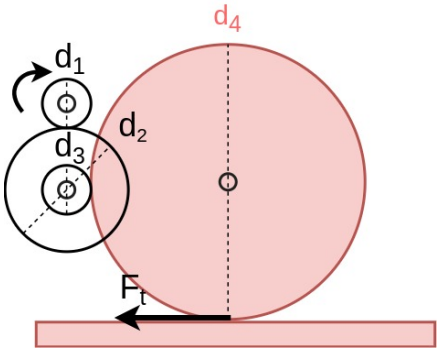


$$d_1 = d_3 = 0.009m, \quad d_2 = 0.017m, \quad d_4 = 0.042m$$

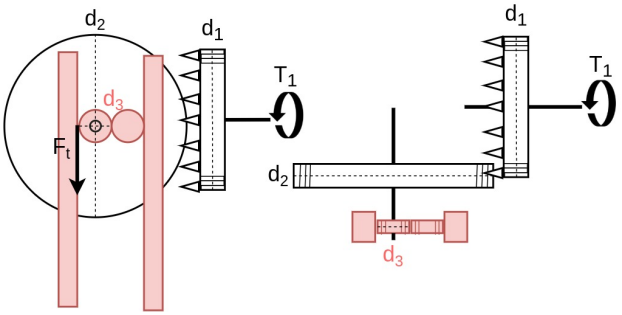
$$T_1 = 0.2Nm, \quad T_3 = T_2 \quad T_4 = \frac{T_3 d_3}{d_1}$$

$$T_4 = \frac{T_1 d_2 d_4}{d_1 d_3} = \frac{T_1 d_2 d_4}{d_1^2} \approx 1.763\ T_1$$

$$F_t = \frac{2T_4}{d_4} = \frac{2T_1 d_2}{d_1^2} \approx 83.951N$$

$$F_f = \mu N = 0.005 * 4.521kg * 9.8m/s^2 = 0.2215N$$

Figure 1. Workings for tangential force and torque ratio of the base movement (horizontal) T - torque, F_t - tangential force



$$d_1 = 0.017m, \quad d_2 = 0.042m, \quad d_3 = 0.009m$$

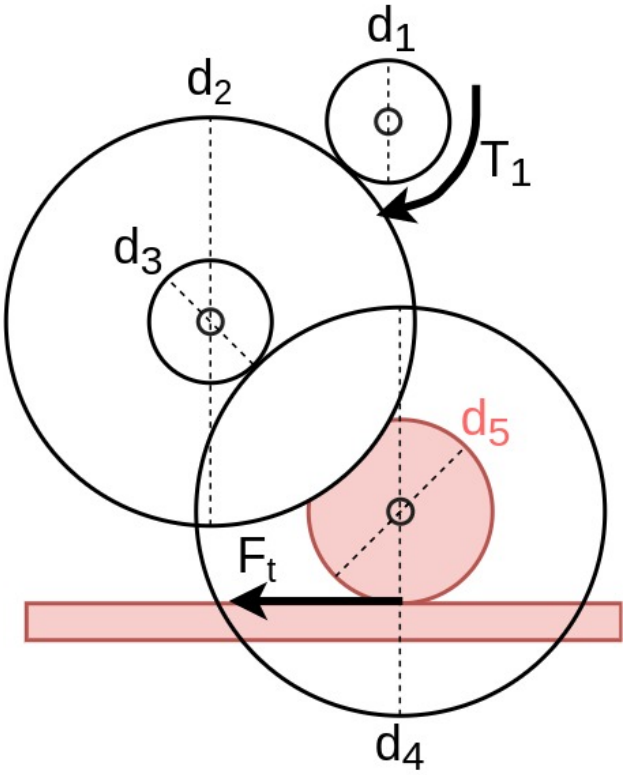
$$T_1 = 0.08Nm, \quad T_3 = T_2 = \frac{T_1 d_2}{d_1}$$

$$T_3 = \frac{d_2}{d_1} T_1 \approx 2.471 T_1$$

$$F_t = \frac{2T_3}{d_3} = \frac{2T_1 d_2}{d_1 d_3} = \frac{2 * 0.08 * 0.042}{0.009 * 0.017} \approx 43.922\ N$$

$$F_f = \mu N = 0.06 * 0.1kg * 9.8m/s^2 = 0.059N$$

Figure 2. Workings for tangential force and torque ratio of the arm movement (horizontal) T - torque, F_t - tangential force



$$d_3 = d_1 = 0.017m, \quad d_4 = d_2 = 0.042m, \quad d_5 = 0.025m$$

$$T_1 = 0.08Nm, \quad T_3 = T_2, \quad T_5 = T_4$$

$$T_4 = \frac{T_3 d_4}{d_3} \quad T_2 = \frac{T_1 d_2}{d_1} \quad F_t = \frac{2T_5}{d_5}$$

$$T_5 = \frac{T_3 d_4}{d_3} = \frac{T_2 d_4}{d_3} = \frac{T_1 d_2 d_4}{d_1 d_3} = \frac{T_1 d_2^2}{d_1^2}$$

$$T_5 = \frac{d_2^2}{d_1^2} T_1 \approx 6.104 T_1$$

$$F_t = \frac{2T_5}{d_5} = \frac{2T_1 d_2^2}{d_5 d_1^2} \approx 39.06\ N$$

$$F_f = \mu N = 0.05 * 0.35kg * 9.8m/s^2 = 0.171N$$

Figure 3. Workings for tangential force and torque ratio of the head movement (horizontal) T - torque, F_t - tangential force