Starting with the gear on the DC Motor:

Diameter = 6mm
No. teeth = 10
Module = 0.5

$$m = \frac{D_p}{N} = \frac{1}{P} = 0.5$$

$$\therefore P = 2$$

Hole diameter = 1.4mm

$$P = \frac{N}{D_p} \Rightarrow D_p = \frac{N}{P} = \frac{10}{2}$$
$$= 5mm.$$

Thickness = 5mm
$\Rightarrow$ face width = 5mm.

$$p = \frac{\pi}{P} = \frac{\pi}{2}$$

$$\text{tooth thickness} \approx \frac{p}{2} = \frac{(\pi/2)}{2} = \frac{\pi}{4}$$

actually measured D_p value is more like

$$\frac{6-5}{2} = \underline{5.5mm}$$

DC Motor speed:

6600 rpm = 691.15 rad/s
(no load)

To CALCULATE TORQUE REQUIRED:

Desired speed:

0.25 m/s $\Rightarrow$ 20 rad/s
(for r = 0.025m)

40 (below)

~~$\omega_1 = 20$~~ rad/s
$\omega_2 = 691.15$ rad/s

$$\frac{\omega_1}{\omega_2} = \frac{20}{691.15} = 0.0289 = \underbrace{\frac{N_2}{N_1}}_{\text{number of teeth if using 1 gear.}}$$

$\Rightarrow$ reduction ratio of $\approx$ 34.5 : 1

$N_2 = 10$, $N_1 = \frac{10}{0.0289} = \underline{346 \text{ teeth}}$. X too much!

SIMPLE gear train: $N_3 = 10$, $\omega_3 = 691$ rad/s, $\omega_1 = 20$ rad/s

$$\frac{\omega_1}{\omega_3} = \frac{N_2}{N_1}\frac{N_3}{N_2} \Rightarrow \frac{N_2 N_3}{N_1 N_2} = \frac{20}{691}$$

does not reduce the size of the final gear, just the direction it turns

$$\frac{10\cancel{N_2}}{N_1\cancel{N_2}} = \frac{20}{691}$$

$$\frac{10}{N_1} = \frac{20}{691}$$

$$N_1 = \frac{691}{2} = \underline{345.5}$$

Using COMPOUND gear train: $\omega_4 = \frac{N_1}{N_2}\frac{N_3}{N_4}\omega_1$

$$\Rightarrow \frac{\omega_4}{\omega_1} = \frac{N_1}{N_2}\frac{N_3}{N_4}$$

$$\frac{691}{20} = \frac{N_1}{N_2}\frac{N_3}{10} \quad \therefore \quad \frac{N_1 N_3}{N_2} = \frac{691}{2}$$

$\geq N_n \geq 10 \Rightarrow N_1$ & N_3 too large.

USING 0.5 m/s $\Rightarrow$ 40 rad/s

$$\frac{\omega_6}{\omega_1}\ \frac{691}{40} = \frac{N_1}{N_2}\frac{N_3}{N_4}\frac{N_5}{10} \Rightarrow \frac{691}{40} = \frac{x}{1000} \quad x = \frac{69100}{4}$$

smallest combo $\Rightarrow N_2 = N_4 (= N_6) = 10$

$N_1 N_3 N_5 = 17275$

$$\boxed{16 \times 27 \times 40 = 17280}$$

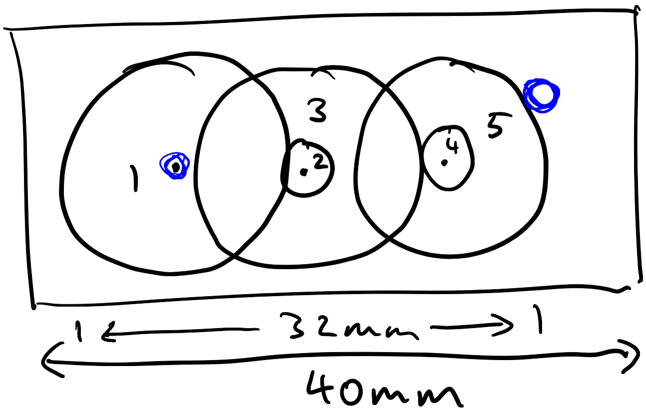
We have: compound gear train,

$N_1 = 50$
$N_2 = 10$
$N_3 = 25$
$N_4 = 10$
$N_5 = 14$
$N_6 = 10$

DESIGNING FOR SPACE LIMITATION:

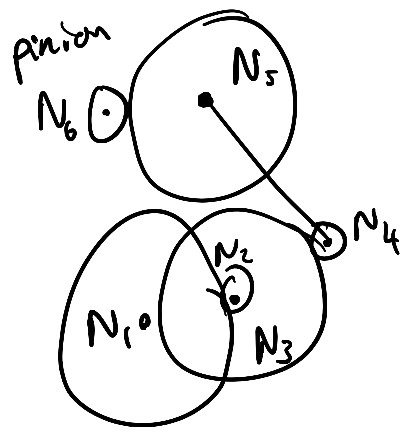
Max length of space = 40mm

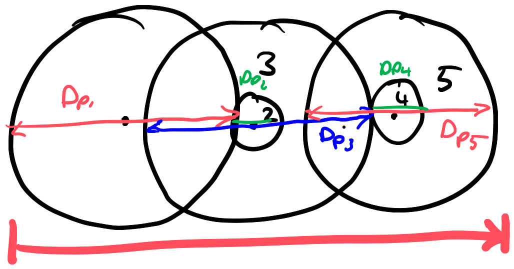
80% = 32 mm

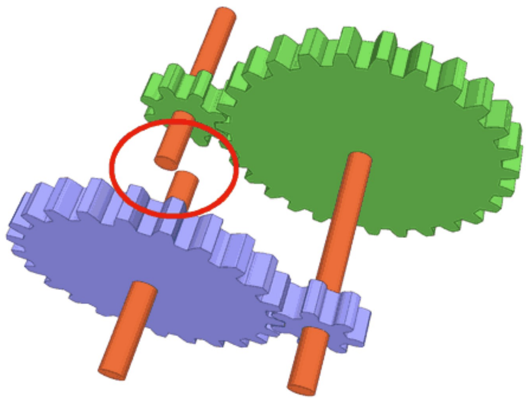


$N_6 \Rightarrow$ dc motor pinion,

$d = 6mm$







$$D_{p_1} + \frac{D_{p_2}}{2} + \frac{D_{p_3}}{2} + \frac{D_{p_4}}{2} + \frac{D_{p_5}}{2}$$

= TOTAL LENGTH

$$\Rightarrow D_{p_1} + \frac{1}{2}\left(D_{p_2} + D_{p_3} + D_{p_4} + D_{p_5}\right) = 32mm$$

$\omega_6 = 691$ rad/s, $N_6 = 10$

$\omega_5 =$ ____ , $N_5 = 14$

$$\frac{\omega_5}{\omega_6} = \frac{N_6}{N_5} \Rightarrow \omega_5 = \frac{10}{14} \times 691 = 493.6 \text{ rad/s.}$$

$$\frac{\omega_6}{\omega_1} = \frac{N_1}{N_2}\frac{N_3}{N_4}\frac{N_5}{N_6} = \frac{691}{40} = 17.275$$

ASSUMING HERE:

D_p follows same rules as N:

$$\frac{\omega_6}{\omega_1} = \frac{D_{p_1}}{D_{p_2}}\frac{D_{p_3}}{D_{p_4}}\frac{D_{p_5}}{D_{p_6}} = 17.275$$

$$\Rightarrow \quad D_{p1} D_{p3} D_{p5} = 691$$

$$D_{p2} D_{p4} D_{p6} = 40$$

($D_{p6} = 6\,mm$, but also not worrying about this due to config.)

$$\Rightarrow D_{p2} D_{p4} = 40$$

$$\Rightarrow D_{p2} = 8\,mm, \quad D_{p4} = 5\,mm$$

$D_{p1} D_{p3} D_{p5} = 691$, $\quad N_1 > N_3 > N_4$

$\quad 50 > 25 > 14$

$$\underset{D_{p1}}{14.4} \times \underset{D_{p3}}{8} \times \underset{D_{p5}}{6} = 691.2$$

So, $D_{p1} + \frac{1}{2}(D_{p2} + D_{p3} + D_{p4} + D_{p5}) = 14.4 + \frac{1}{2}(8 + 8 + 5 + 6)$

$$= \underline{27.9\,mm}$$

Sooo, can increase: $17 + \frac{1}{2}(8 + 10 + 5 + 7)$

$$= \underline{32\,mm.}$$

$D_{p1} = 17\,mm$, $N_1 = 50$

$D_{p2} = 8\,mm$, $N_2 = 10$

$D_{p3} = 10\,mm$, $N_3 = 25$

$D_{p4} = 5\,mm$, $N_4 = 10$

$D_{p5} = 7\,mm$, $N_5 = 14$

($D_{p6} = 6\,mm$, $N_6 = 10$)

$$a = m = \frac{D_p}{N}$$

$$d = 1.25\,m$$

Gear Parameters:

Gear 6 = driving DC motor pinion.

Pitch Diameter, D_p [mm]

Number teeth, N

Diametral pitch, $P = \frac{N}{D_p}$ [1/mm]

Addendum, $a = m = \frac{D_p}{N}$ [mm]

Dedendum, $d = 1.25m$ [mm]

Base circle diameter, $D_b = D_p \cos\phi$ [mm]

Tooth depth, $I = a + d$ [mm]

Tooth thickness, $t = \frac{\pi m}{2}$ [mm]

Design for Meshing:

$m = 0.5$

$$P = \frac{N}{D_p}$$

$$a = m = \frac{1}{P} = \frac{D_p}{N}$$

$$\therefore D_p = 0.5N$$

$D_{p_1} = 20$

$D_{p_2} = 5$

$D_{p_3} = 14$

$D_{p_4} = 5$

$D_{p_5} = 8$

$D_{p_6} = 5$

$$D_{p_1} + \frac{D_{p_2}}{2} + \frac{D_{p_3}}{2} + \frac{D_{p_4}}{2} + \frac{D_{p_5}}{2} = 20 + \frac{1}{2}(5+14+5+8+5)$$

bigger!

$$= 20 + 37 = 57 \text{ [mm]}$$