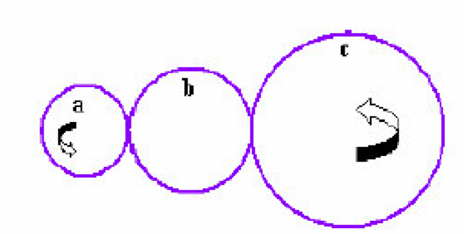
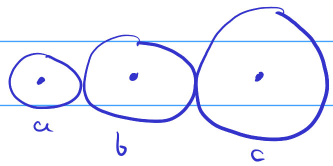
1. If the output torque T_c must be $3T_a$ in Fig. 1, how many teeth should gears b and c have? Given gear a has 26-teeth.



N: no. teeth

1)



$$\frac{N_c}{N_a} = \frac{\cancel{N_b}}{\underbrace{N_a}_{26}} \times \frac{N_c}{\cancel{N_b}} = \frac{T_c}{T_a} = 3 \rightarrow N_c = 78$$

* N_b = any number (it gets cancelled)

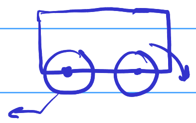
b is just an idle gear that changes the direction of rotation

it just divides the speed reduction from a to c into two stages: a→b then b→c

2. A motor rated at 5000 rpm is used to turn the 50 mm-diameter wheels of a mobile robot. The robot is required to travel a 600 mm distance in about 8(sec). To this end, the motor angular velocity is to be geared down using a gear system. The available gear teeth are 10, 20, 50, and 100.
   - Find a proper gear system combination that achieves this objective as closely as possible.
   - The motor inertia is $0.7\times10^{-7}\ kgm^2$ and the wheel inertia is 20 times the motor inertia. Given the motor torque of 2.5 mNm, what will be the wheel's angular acceleration for the gear system designed in the previous part?

$v = \frac{600}{8}$ mm/sec

* let G be reduction ratio
* let $\omega_{wheel} = \frac{1}{G}\omega_{motor}$



5000 rpm = motor rpm

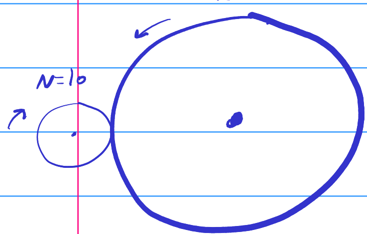
d = 50 mm

$$v = \omega_{wheel} \cdot r = \left(5000 \times \frac{2\pi}{60} \times \frac{1}{G}\right) \cdot \left(\frac{50}{2}\right) = \frac{600}{8}\ mm/s$$

$\longrightarrow G \simeq 175$

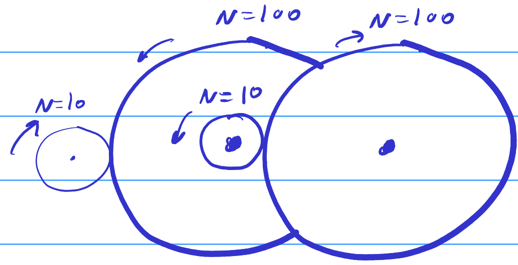
* Using available gears:

1. use the highest reduction ratio



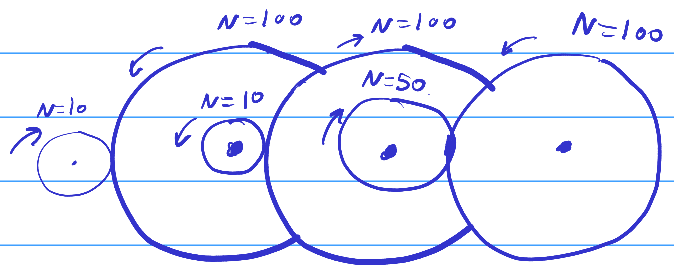
$G = \frac{100}{10} = 10$

2. add another stage

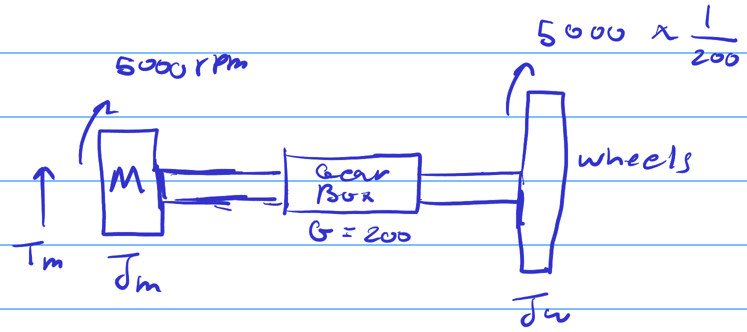


$G = \frac{100}{10} \times \frac{100}{10} = 100$

3. add final stage



$$G = \frac{100}{10} \times \frac{100}{10} \times \frac{100}{50} = 200$$ ← closest to 175



$$\boxed{J_{eq}\,\alpha = T_{meq}}$$

we need to find equivalent inertia and torque
1. transfer Jm to the wheel and add it to the wheel (J_{eq})
2. transfer Tm to the wheel (T_{meq})

$T_{meq} = 200\,T_m$

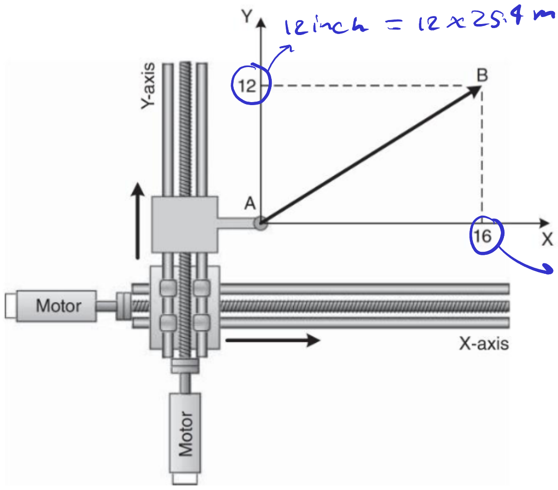
$J_{eq} = J_m \times 200^2 + J_w$

20 J_m

$$\alpha = \frac{200 \times 2.5 \times 10^{-3}}{0.7 \times 10^{-7} \times 200^2 + 0.7 \times 10^{-7}} = 178.566 \text{ rad/s}^2$$

3. Consider the machine shown in the Figure below. If both axes are moving at the speed of 101 mm/s using trapezoidal velocity profile with $t_a = 0.2$ s, how long will it take each axis to complete its move?

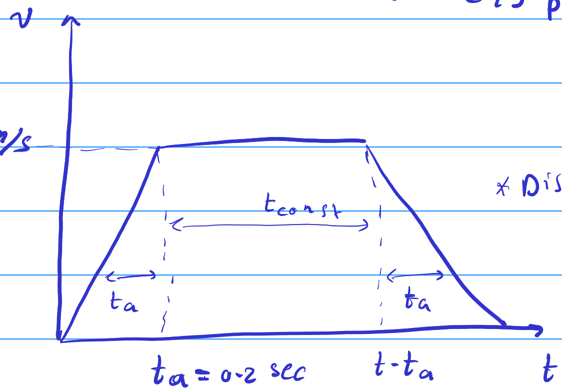
12 inch = 12 x 25.4 mm



16 inch = 16 x 25.4 mm

Figure : Multiaxis machine

Trapezoidal velocity profile



* Distance = Area under the curve

↳ acceleration time

axis x:

$$16 \times 25.4 = 2\left(\tfrac{1}{2} \times 0.2 \times 101\right) + 101 \times t_{const} \longrightarrow t_{const} = 3.82 \text{ sec} \longrightarrow t = t_{const} + 2 \times t_a = 4.22 \text{ sec}$$

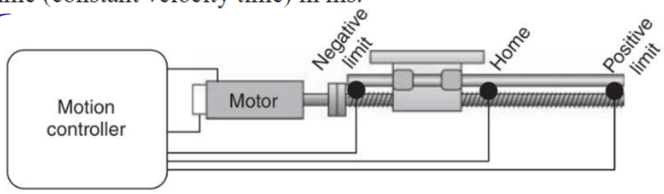
axis y

$$12 \times 25.4 = 2\left(\tfrac{1}{2} \times 0.2 \times 101\right) + 101 \times t_{const} \longrightarrow t_{const} = 2.8 \text{ sec} \longrightarrow t = t_{const} + 2 \times t_a = 3.22 \text{ sec}$$

note: the axes will arrive at their desired positions in different times

either axis x should move faster or y should move slower

4. Motion controllers use counts (cts) to track position. The motor in the Figure below has an encoder that produces 8000 cts/rev. The ball-screw advances 10 mm/rev. A motion application requires the carriage of the linear axis to travel 406 mm at 101 mm/s with an acceleration of 254 mm/s^2. Calculate the following parameters for the carriage in the units shown: speed (cts/ms), distance (cts), acceleration (cts/ms^2), and move time (constant velocity time) in ms.



$s = 10^3\ ms$

$$cts/mm = 8000\ \overset{counts}{cts}/rev \times \frac{1}{10}\ rev/mm = \boxed{800\ cts/mm}$$

$$speed\ (cts/\underset{milisecond}{ms}) = 800\ cts/mm \times 101\ mm/\underset{10^3\ ms}{s} = \frac{800 \times 101}{10^3} = 80.8\ cts/ms$$

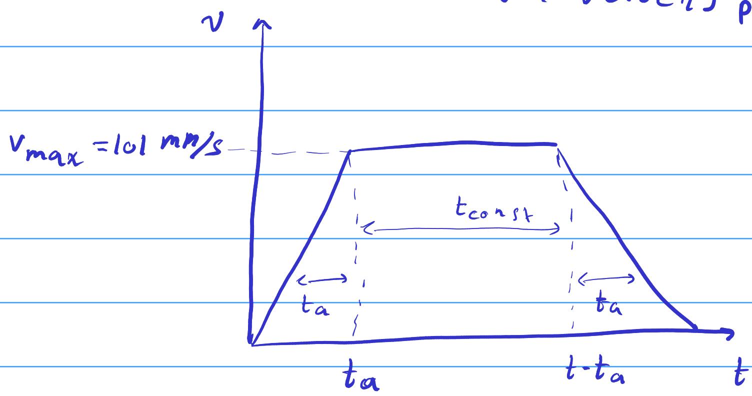
$$distance\ (cts) = 800\ cts/mm \times 406\ mm = 324\ 800\ cts$$

$$acceleration\ (cts/ms^2) = 800\ cts/mm \times 254\ mm/\underset{10^3\ ms}{s}^2 = \frac{800 \times 254}{(10^3)^2} = 0.2032\ cts/ms^2$$

to get move time, we must assume a motion profile

assuming a trapazoidal motion profile:

Trapazoidal velocity profile



Givens:

$v_{max} = 101\ mm/s$ $\quad d = 406\ mm$

$a = 254\ mm/s^2$

$\therefore t_a = \frac{v_{max}}{a} = 0.3976\ sec$

distance = Area

$$406 = 2\left(\tfrac{1}{2} \times 0.3976 \times 101\right) + 101\ t_{const} \longrightarrow t_{const} = 3.62\ sec$$