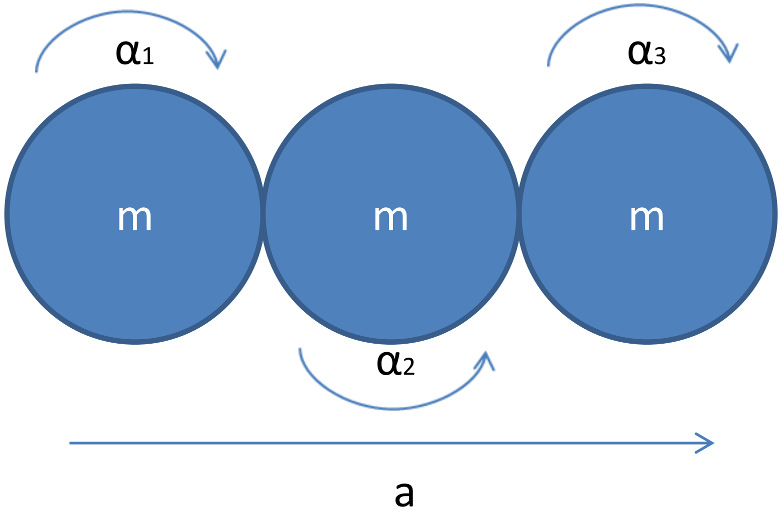
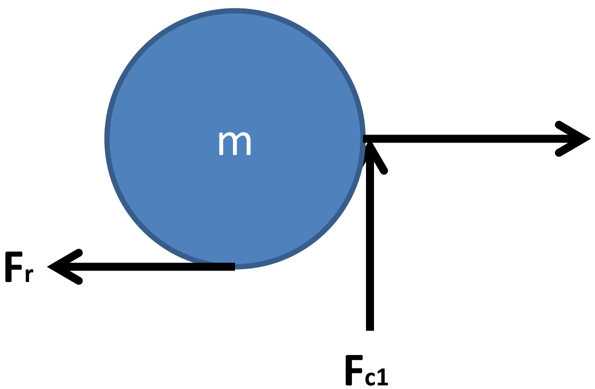
First Condition:

- $a_1 = a_2 = a_3 = a$
- $\alpha_1 = -\alpha_2 = \alpha_3$
- $\alpha_1 = \alpha_3 = \alpha$
- $\alpha_2 = -\alpha$



FBD of roller 1



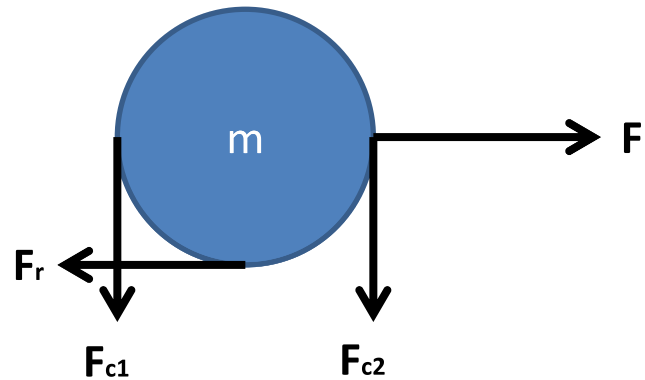
$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r - F_{c1}) \cdot r = I \cdot \alpha$$

FBD of roller 2



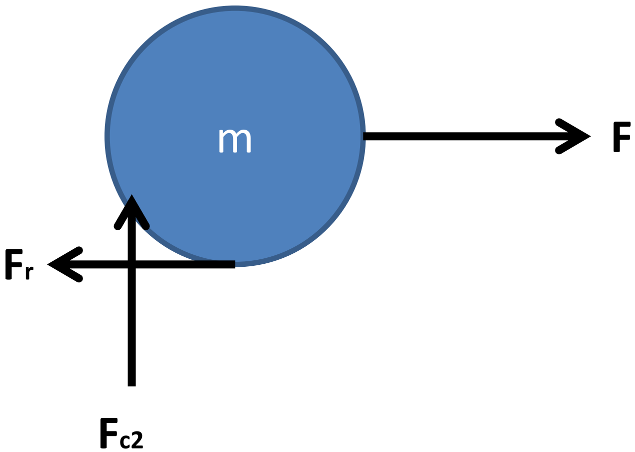
$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r - F_{c1} + F_{c2}) \cdot r = -I \cdot \alpha$$

FBD of roller 3



$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r + F_{c2}) \cdot r = I \cdot \alpha$$

$$\begin{array}{r} (F_r - F_{c1}) \cdot r = I \cdot \alpha \\ (F_r + F_{c2}) \cdot r = I \cdot \alpha \\ \hline (-F_{c1} - F_{c2}) \cdot r = 0 \end{array}$$

$$\boxed{-F_{c2} = F_{c1}}$$

$$\begin{array}{r} (F_r - F_{c1} + F_{c2}) \cdot r = -I \cdot \alpha \\ (F_r + F_{c2}) \cdot r = I \cdot \alpha \\ \hline -F_{c1} = -{}^{2I \cdot \alpha}/_{r} \end{array}$$

$$\boxed{F_{c1} = {}^{2I \cdot \alpha}/_{r}}$$

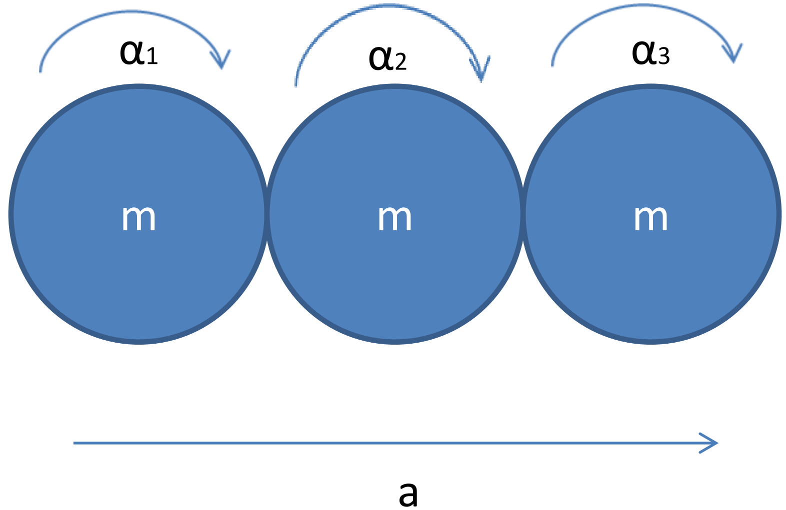
$$\left(F_r - {}^{2I \cdot \alpha}/_{r}\right) \cdot r = I \cdot \alpha$$

$$F_r = {}^{3I \cdot \alpha}/_{r}$$

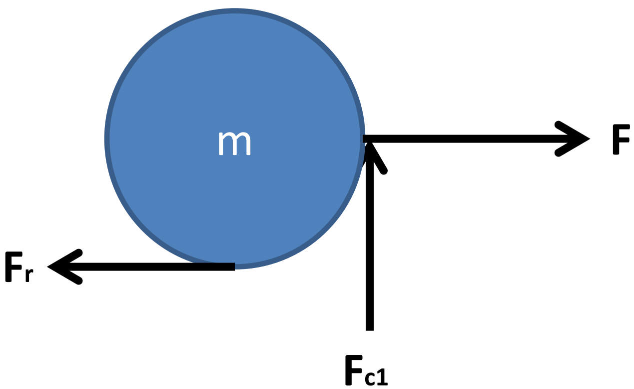
$$\boxed{\text{Thus, } \alpha = \frac{F_r \cdot r}{3I}}$$

Second Condition:

- $a_1 = a_2 = a_3 = a$
- $\alpha_1 = \alpha_2 = \alpha_3 = \alpha$



FBD of roller 1



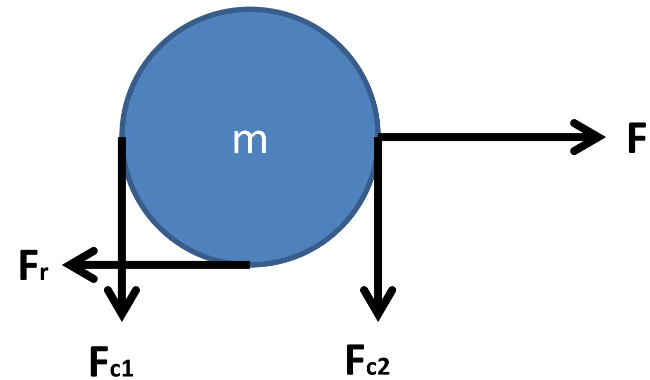
$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r - F_{c1}) \cdot r = I \cdot \alpha$$

FBD of roller 2



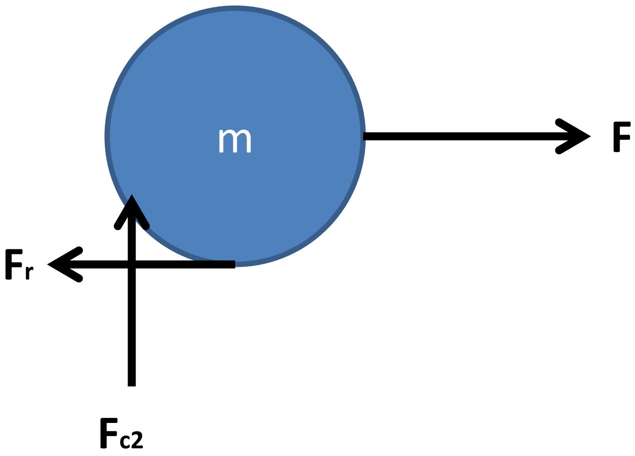
$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r - F_{c1} + F_{c2}) \cdot r = I \cdot \alpha$$

FBD of roller 3



$$\sum F = m \cdot a$$

$$F - F_r = m \cdot a$$

$$\sum T = I \cdot \alpha$$

$$(F_r + F_{c2}) \cdot r = I \cdot \alpha$$

$$\begin{array}{rl} (F_r - F_{c1}) \cdot r = I \cdot \alpha & \\ (F_r + F_{c2}) \cdot r = I \cdot \alpha & - \\ \hline (-F_{c1} - F_{c2}) \cdot r = 0 & \end{array}$$

$$\boxed{-F_{c2} = F_{c1}}$$

$$\begin{array}{rl} (F_r - F_{c1} + F_{c2}) \cdot r = I \cdot \alpha & \\ (F_r + F_{c2}) \cdot r = I \cdot \alpha & - \\ \hline -F_{c1} = 0 & \end{array}$$

$F_{c1} = 0$, thus $F_{c2} = 0$, which means that the rollers don’t contact each other

$$(F_r - 0) \cdot r = I \cdot \alpha$$

$$F_r = {}^{I \cdot \alpha}/_{r}$$

Thus, $\alpha = \frac{F_r \cdot r}{I}$

Discussion;

- Mopping depends on the value of F_r and α.
- F_r is the force to remove the dirt on the floor.
- α affects the number of rolling within a specific time frame. More α means more rolling, thus means more mopping action. We can conclude that more α means better mopping efficiency.
- The value of F_r of either first and second condition is the same (depends on the weight of the total assembly), while the value of α of the first and second condition can be compared.
- It is found that the value of α of the second condition is 3 times higher than that of the first condition. Thus we can conclude that second condition has better mopping efficiency than first condition.