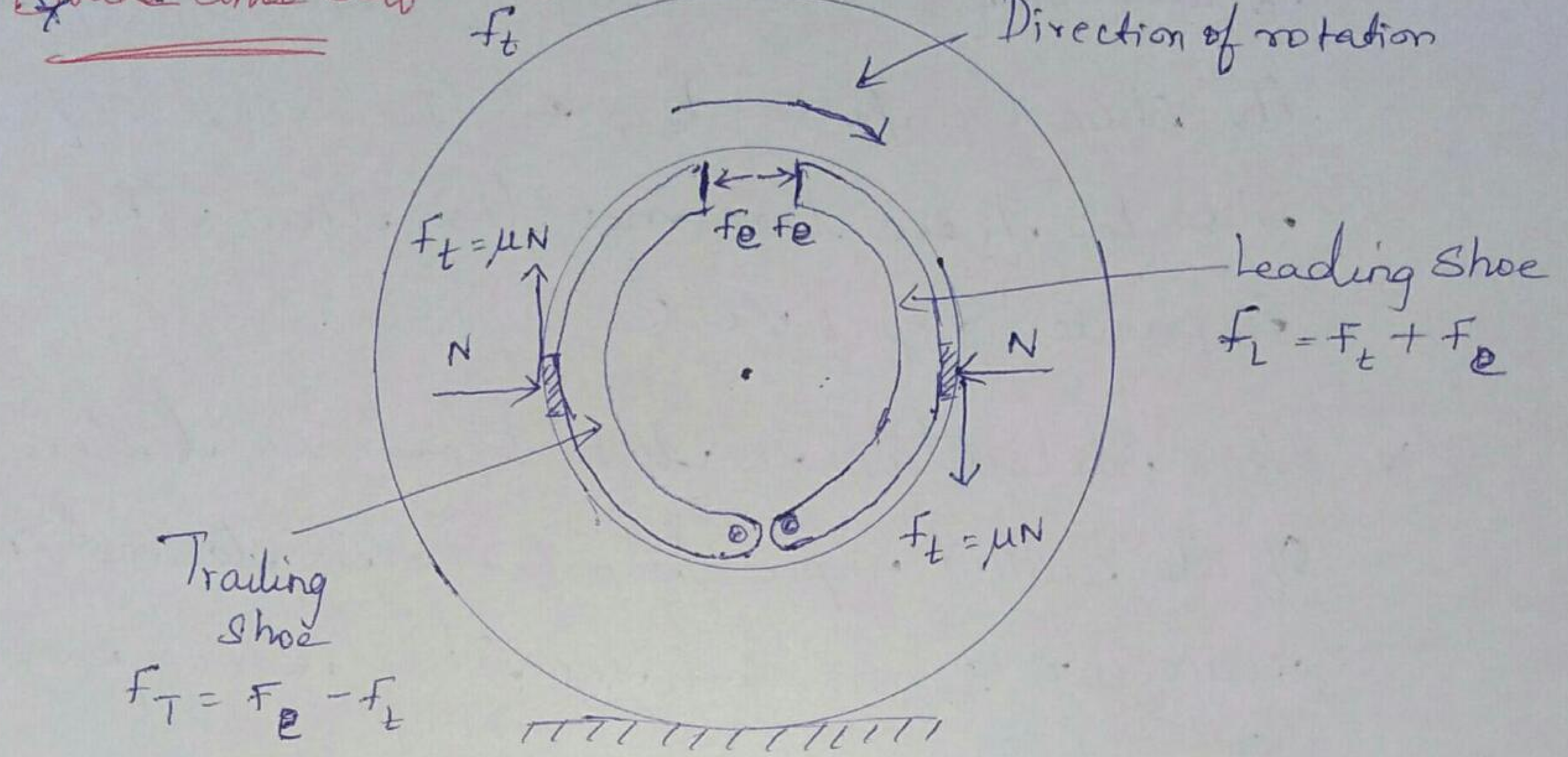
# Design of Drum Brake

## Brake Shoe Self Energization:




* The friction force or drag on the right hand shoe tends to move in the same direction as the shoe tip force $F_e$, which produce it.
* Accordingly this helps to drag the shoe onto the drum
* So that the shoe tip force is raised effectively above that of the original expander force.
* This increase in shoe tip force above the input expander force is termed as positive servo, and shoes that provide this self-energizing or servo action known as leading shoe

∴ The leading shoe resultant force $F_L = F_e + F_t$

* Likewise in the left hand shoe, the frictional force or drag $F_t$ tends to oppose the shoe tip force $F_e$, so that the effective shoe tip force becomes less than the expander input force

* This reduction in shoe tip force below that of the initial input tip force is termed as negative servo, and the shoe which provide this de-energizing action are known as trailing shoes.

∴ The trailing shoe tip resultant force, $F_T = F_e - F_L$

## Retarding wheel and Brake drum torque

The maximum retarding wheel torque is limited by wheel slip and is given by

$$T_W = \mu_a W R$$

where,

$T_W \rightarrow$ wheel retarding torque

$\mu_a \rightarrow$ adhesion factor

$W \rightarrow$ vertical load on wheel

$R \rightarrow$ wheel Rolling radius

The torque, produced at this brake drum caused by the frictional force between the lining and the drum, is required to bring the wheel to rest and is given by

$$T_B = \mu N r$$

Where,

$T_B \rightarrow$ Brake drum Torque

$\mu \rightarrow$ Coefficient of friction b/w lining and drum

$N \rightarrow$ Radial force b/w lining and drum

$r \rightarrow$ Drum radius

Both these wheel and drum torque must be equal up to the point of wheel slip and they act in the opposite direction to each other

$$T_B = T_W$$

$$\mu N r = \mu_a W R$$

Force between lining and drum, $N = \frac{\mu_a W R}{\mu r}$

## Shoe and Brake Factor

* If the ~~[illegible]~~ Brake is designed to produce a high braking force using a 'low effort', it has a high self energizing or servo action.

* This desirable property is attained at the expense of stability because any change in friction affects torque output disproportionately.

* The multiplication of effort or self energizing characteristics for each shoe is known as Shoe factor.

* The Shoe factor is defined as the ratio of the tangential drum drag $F_t$ at the shoe periphery to the force $F_c$ applied by the expander at the shoe tip

$$\text{Shoe factor } S = \frac{\text{Tangential drum force}}{\text{Shoe tip force}} = \frac{F_t}{F_c}$$

* The combination of different Shoe arrangement such as leading and trailing Shoes, two leading shoes, two trailing Shoes etc produce a brake factor B that

is the sum of the individual shoe factor

Brake factor = Sum of shoe factors

$B = (S_L + S_T),\ 2S_L,\ 2S_T$ and $(S_p + S_s)$

## Effecting of expanding mechanism of shoes on total braking torque

In conventional brakes with internal shoes, two types of expanding mechanisms are applied. In one type the actuating force on each shoe are equal.

Hence, $W_t = W_l = W_a$

Therefore, total braking torque, $T = T_l + T_t$

$$\frac{W_a m \mu_f k}{n \sin\theta - \mu_f (k-n)\cos\theta} + \frac{W_a m \mu_f k}{n \sin\theta + \mu_f (k - n\cos\theta)} = \frac{2 W_a m \mu_f k n \sin\theta}{n^2 \sin^2\theta - \mu_f^2 (k - n\cos\theta)^2}$$

The second type of mechanism gives the shoes equal displacement and hence the actuating forces are in fixed ratio

$$\frac{W_t}{W_l} = \frac{n \sin\theta + \mu_f (k - n\cos\theta)}{n \sin\theta - \mu_f (k - n\cos\theta)}$$

# Calculation of Mean Lining Pressure and Heat Generation during Braking operation.

The following assumptions are made

(i) The lining are Symmetrical

(ii) Force $P_l$ and $\mu P_l$ act in the lining contact centre point of leading shoe

(iii) Force $P_t$ and $\mu P_t$ act in the lining contact centre point of trailing shoe

(iv) Force $P_t$ and $P_l$ are equal

(v) The value of $\mu_f$ is independent of pressure and velocity

Let, $R \rightarrow$ Effective wheel radius

$r \rightarrow$ Brake drum radius

$w \rightarrow$ Brake lining width

$\alpha \rightarrow$ contact angle of each lining

$W \rightarrow$ Weight of vehicle.

Now if the speed of vehicle is brought down from U to V in a distance of S, then retardation

$$\cancel{f} = \left(\frac{v}{3.6}\right)^2$$

$$\boxed{f = \frac{U^2 - V^2}{2S}}$$

Braking force, $F = (W/g) f$ (when vehicle moves on level road)

$F = (W/g) f + W \sin\theta$ (when it moves down a gradient)

Assuming braking force on each wheel to be same

$$\text{Braking Torque on each wheel} = (F/4) R.$$

$$\text{Braking Torque on Drum} = (\mu_f P_l + \mu_f P_t) r$$

$$= 2\mu_f . P . r \quad (\text{if } P_l = P_t = P)$$

Therefore

$$2\mu_f P . r = (F/4) R.$$

$$\boxed{P = \frac{FR}{8\mu_f r}}$$

Area of lining = Lining width × Radius × Arc Subtended at center.

$$= w r \frac{\alpha \pi}{180}$$

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$$\text{Mean lining pressure} = \frac{P}{\text{Area of lining}} = \frac{F R}{8 \mu_f r}$$

$$= \frac{\frac{FR}{8\mu_f r}}{\frac{\omega r \alpha \pi}{180}} \Rightarrow \frac{FR}{8\mu_f r} \times \frac{180}{\omega r \alpha \pi}$$

$$\boxed{\text{Mean lining pressure} = \frac{180}{8\pi} \times \frac{FR}{\mu_f r^2 \omega \alpha}}$$

Workdone in braking = Braking force × Distance moved

$= F \times S$

Amount of heat generated during braking operation $= FS$

Therefore, Heat generated at each wheel $= \frac{FS}{4}$

Heat generated per second at each wheel $= \frac{FV}{4}$

Where, V is the speed