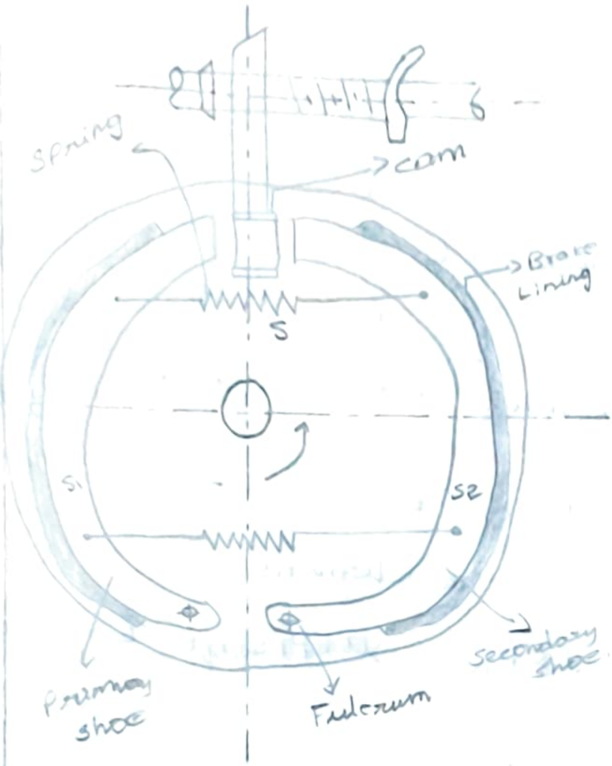
INTERNAL EXPANDING SHOE BRAKE:-

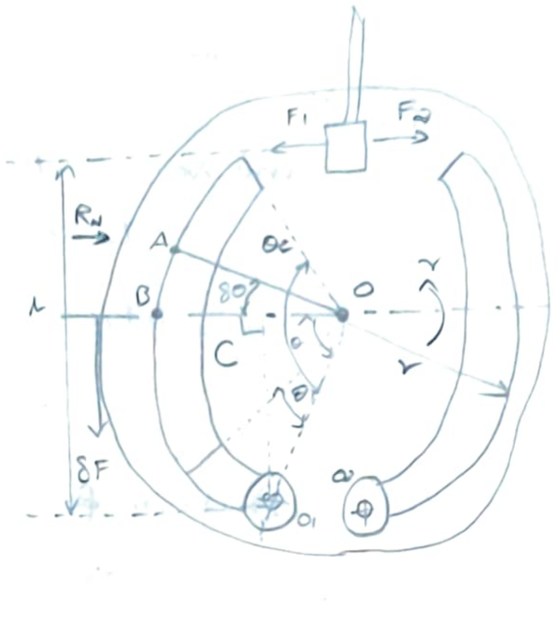
Working Principle:-

Fig. shows an internal shoe automobile brake. It consists of two semi-circular shoes S_1 and S_2 which are lined with a frictional material such as Ferrodo. When brakes are applied, cam rotates which pushes the shoes outwards to press the brake lining against the rim of the drum. As soon as the brakes are ~~off~~, the shoes are pushed inside by the spring.

It may be noted that for the anti clockwise direction, the left side shoe is known as primary (or) leading shoe while the right hand shoe is known as trailing (or) secondary shoe



a) internal expanding brake



b) forces on the brake

Determination of Pressure and brake Torque:-

Consider the forces on the brake when the drum rotates in anticlockwise direction, as shown in fig...,

P_1 = Maximum intensity of normal Pressure

P_N = Normal Pressure,

r => Internal radius of the drum.

b => width of brake lining.

T_B = Braking Torque.

R_N => Normal force..

M_N => Moment of Normal force

M_F => Moment of frictional force

Consider a small element AB of brake lining subtending an angle $\delta\theta$ at the centre of the drum. join O_1 to O. It is assumed that the Pressure distribution on the shoe is nearly uniform

The rate of wear of the shoe lining varies directly as the perpendicular distance from O_1 to ie, O_1C

From the geometry,

$$O_1C = OO_1 \sin\theta$$

and Normal Pressure at B,

$$P_N \propto \sin\theta \quad \text{(or)} \quad P_N = P_1 \sin\theta.$$

δR_N = Normal Pressure $\times$ Area of the element planed

$$\Rightarrow P_N \times (b.r.\delta\theta) = P_1 \sin\theta\, b.r.\delta\theta$$

Friction force on the element,

$$\delta F = \mu.\delta R_N = \mu.P_1 \sin\theta.br.\delta\theta$$

$$\delta T_B = \delta F.r$$

$$= \mu P_1 \sin\theta.br.\delta\theta.r.$$

$$\Rightarrow \mu P_1 \sin\theta.br\,\delta\theta.$$

$$T_B = \mu P_1 br^2 \int_{\theta_1}^{\theta_2} \sin\theta.d\theta = \mu P_1 br^2(\cos\theta_1 - \cos\theta_2)$$

$$\delta M_N = \delta R_N \propto O_1C$$

$$\Rightarrow P_1 \sin\theta(b.r.\delta\theta)(OO_1 \sin\theta)$$

$$\Rightarrow P_1 \sin^2\theta(b.r.\delta\theta)\,OO_1$$

$$M_N = P_1.b.r.OO_1 \int_{\theta_1}^{\theta_2} \sin^2\theta\, d\theta$$

$$\Rightarrow \tfrac{1}{2} P_1.b.r.OO_1 \left[(\theta_2-\theta_1) + \tfrac{1}{2}(\sin 2\theta_1 - \sin 2\theta_2)\right]$$

Moment of frictional force δF about the fulcrum O_1,

$$\delta M_F = \delta F \times BC = \delta F(r - OO_1.\cos\theta)$$

$$\delta M_F = \mu P_1.br\left[r\sin\theta - \frac{OO_1 \sin 2\theta}{2}\right]\delta\theta$$

Total Moment of frictional force,

$$M_F = \mu p_1 \cdot b \cdot r \int_{\theta_1}^{\theta_2} \left[r\sin\theta - \frac{OO_1 \sin 2\theta}{2} \right] d\theta$$

$$\Rightarrow \mu p_1 \cdot b \cdot r \left[r(\cos\theta_1 - \cos\theta_2) + \frac{OO_1}{4} (\cos 2\theta_2 - \cos 2\theta_1) \right]$$

For leading shoe, take Moments about O_1,

$$F_1 \times l = M_N - M_F \quad \text{(or)} \quad F = \frac{M_N - M_F}{l}$$

and for trailing shoe, take Moments about O_2,

$$F_2 \times l = M_N + M_F \quad \text{(or)} \quad F_2 = \frac{M_N + M_F}{l}$$

condition for self-Locking:-

If $M_F > M_F$, then the brake becomes self-locking.

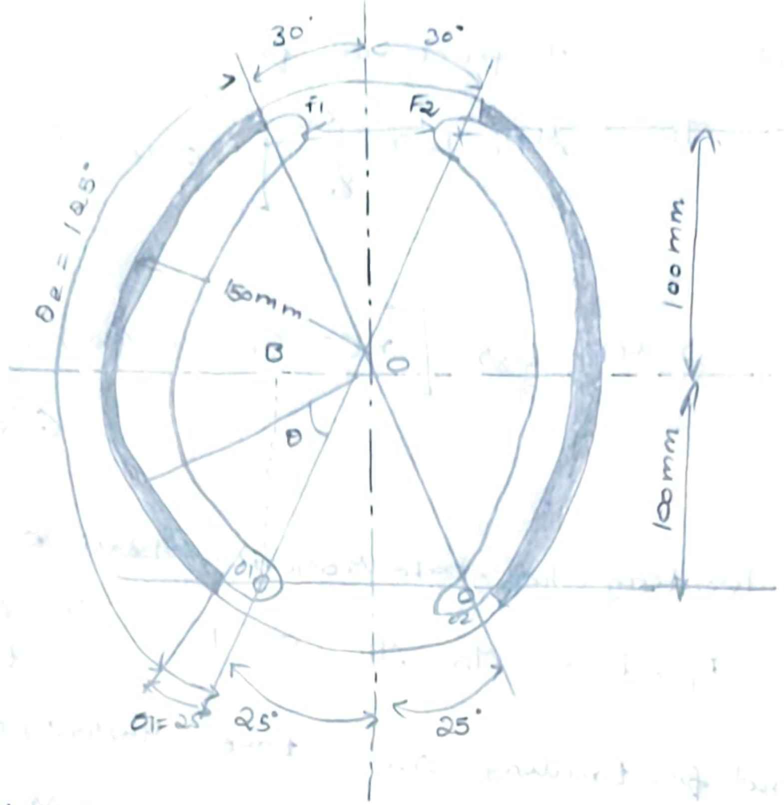
Fig shows the arrangement of two brake shoes which act on the internal surface of a cylindrical brake drum. The braking forces F_1 and F_2 are applied as shown and each shoe pivots on its fulcrum O_1 and O_2. The width of the brake forces F_1 and F_2 are applied as shown and Each shoe pivots on its fulcrum. The width 35 mm and the intensity of pressure at any point A is $4\times10^5 \sin\theta$ N/m^2, where θ is measured as shown from either pivot. The co-efficient of friction is 0.40. Determine the braking Torque and the magnitude of the forces F_1 and F_2.

Given Data:-

$b = 35mm$, $P_N = 4\times10^5 \sin\theta \ N/m^2$; $\mu = 0.4$.

To find : 1) Braking Torque (T_B) and

2) Magnitude of the forces F_1 and F_2



Solution:-

Intensity of normal pressure is given as,

$$P_N = 4\times10^5 \sin\theta \ N/m^2$$

Then, Maximum intensity of pressure,

$$P_1 = 4\times10^5 \ N/m^2.$$

i) Braking Torque (T_B):-

Distance of force F_1 from fulcrum O_1,

$$l = 200mm = 0.2m.$$

Dist of force F_2 from fulcrum O_2.

$$l = 200mm = 0.2.$$

$$T_B = \mu P_1 \cdot b \cdot r^2 (\cos\theta_1 - \cos\theta_2)$$

$$\Rightarrow 186.46 \ N\text{-}m.$$

$$T_B = 2\times186.46 = 372.92 \ N\text{-}m.$$

ii) Magnitude of the forces F_1 and F_2:-

$$\theta_1 = 25° = 25° \times \frac{\pi}{180} = 0.436 \text{ rad}$$

$$\theta_2 = 125 = 2.18 \text{ rad}$$

From the geometry,

$$OO_1 = \frac{O_1B}{\cos 25^\circ} = \frac{100}{\cos 25^\circ} = 110.34\,mm$$

$$M_N = \frac{1}{2} P_1 \cdot b \cdot r \cdot OO_1 \left[(\theta_2 - \theta_1) + \frac{1}{2}(\sin 2\theta_1 - \sin 2\theta_2) \right]$$

$$\Rightarrow \frac{1}{2} \times 4 \times 10^5 \times 0.035 \times 0.15 \times 0.11034 \left[(2.18 - 0.436) + \frac{1}{2}(\sin 50^\circ - \sin 250^\circ) \right]$$

$$\Rightarrow 300.86\,N\text{-}m.$$

$$M_F = \mu P_1 \cdot b \cdot r \left[r(\cos\theta_1 - \cos\theta_2) + \frac{OO_1}{4}(\cos 2\theta_2 - \cos 2\theta_1) \right]$$

$$\Rightarrow 163.65\,N\text{-}m.$$

For leading shoe..,

Taking Moments about the fulcrum O_1, we get.,

$$F_1 \times l = M_N - M_F$$

$$F_1 \times 0.200 = 300.86 + 163.65$$

$$F_1 = 686.05\,N.$$

For trailing shoe:-

$$F_2 \times l = M_N + M_F$$

$$F_2 \times 0.2 = 300.86 + 163.65$$

$$F_2 = 2322.55\,N$$

External contracting shoe brakes:-

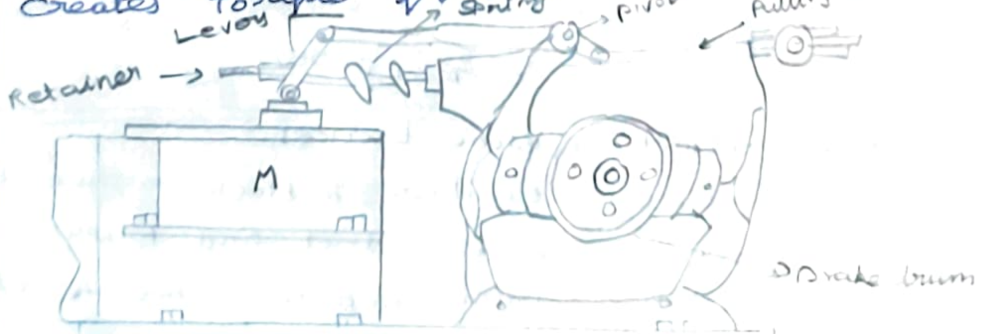
As discussed earlier, in block (or shoe) brakes the shoes are brought in contact and pressed on external brake drum surface. Thus the block brakes often called externally contracting (or) closing brakes the construction and working principles same as that of the external contracting clutch such brakes are commonly used in a lift (or) elevato

Construction and Working Principle:

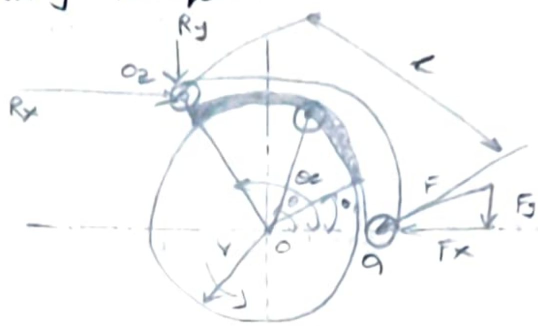
An externally contracting brake uses in a hoist. Since it is used in hoisting device, the friction Torque remains applied upon the drum all the time; except, when the drum is required to move The spring is kept compressed between retainer and left side brake shoe lever. The displacement of arm causes the pivot to move towards right. Then the link turns upwards about pivot and pulling rod moves towards left.

Becaus of this, the right hand lever is pulled towards left, thus pressing its shoe on the drum thus both the shoes pressed against the drum and hence it remains stationary, even if the lift (or) hoist is loaded.

When the Machine is required to operate moving up (or) down, an electric current is allowed to flow through the electric Motor coupled with the drum. At the same time the current flows through M which houses an electroMagnet As soon as the current is cut through the circuit, the Magnet releases the pulling rod and spring forces brings the left and right hand shoe levers closer. Thus it creates Torque friction Torque on the drum



Determination of Braking Torque:-



Consider the forces on the brake, when the drum Rotates in anticlockwise direction, as shown in fig.

The Moments of ~~Interna~~ the frictional and normal forces about the hinge pin are the same as for the internal expanding shoe

Therefore moment of Normal force:

$$M_N = \frac{1}{2} P_1 \cdot b \cdot r \cdot OO_1 \left[(\theta_2 - \theta_1) + \frac{1}{2}(\sin 2\theta_1 - \sin 2\theta_2) \right]$$

and Moment of frictional force:

$$M_F = \mu P_1 \cdot b \cdot r \left[r(\cos\theta_1 - \cos\theta_2) + \frac{OO_1}{4}(\cos 2\theta_2 - \cos 2\theta_1) \right]$$

Thus actuating force, (F) is given by:

$$F = \frac{M_N - M_F}{l}$$

Heat Generated in brakes:-

The heat is generated in the brake during braking operation due to rubbing between the block (or band) and the drum. In fact this heat is nothing but the work done against the friction

Heat Generated H_g = friction force × Rubbing Velocity

$$\Rightarrow F \times V = (\mu R_N) \times V$$

$$H_g = \mu P A V$$

μ = Co-efficient of friction

p = Average Pressure $= \frac{R_N}{A}$

R_N => Normal reaction

Heat Dissipated in Brakes:

The Heat generated due to friction should be dissipated.

$$H_d = C \cdot A \cdot \Delta T = C \times A \, (t_s - t_a).$$

H_d = Rate of Heat dissipation in watts.

C = overall heat transfer co-efficient in $W/m^2\,°C$

=> $29.5\ W/m^2\,°C$ for $\Delta t = 40°C$

t_a => Ambient temperature in °C.