BRAKE

- BRAKE
  - Mechanical Brake [Low power absorbtion]
    - Axial Brake
    - Radial Brake
      - Block | Shoe Brake
        - Short Shoe Brake
        - Long Shoe Brake
      - Band Brake
        - Simple Band Brake
        - Differential Band Brake
      - Band- Block Brake
  - Electrical Brake
  - Hydraulic Brake
  - Pneumatic Brake

(Electrical, Hydraulic and Pneumatic Brake) Used for high power absorbtion

⟹ Brake is defined as a mechanical device which is used to retard the speed of a moving member or to bring the moving member into a stationary condition or to hold the body at rest.

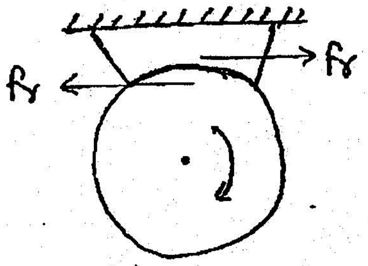
- Brake perform above function by offering frictional resistance to the moving member (Rotating drum) by a stationary member like shoe.

<u>Axial Brake</u>:- Force applied for Braking in an axial direction

<u>Radial Brake</u>:- Force applied for Braking in an radial direction.

Case 1 :- Prime mover

'P' , N

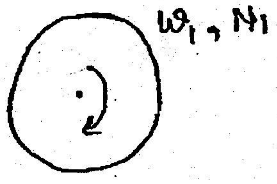


$$P = \frac{2\pi N T_f}{60}$$

T_f = known

HOW TO CALCULATE T_f

Case 2 Not a prime mover



$$\omega_2 = \omega_1 + \alpha t$$

α = known

$\Downarrow$

$$\boxed{T_f = I\alpha}$$

If Distance is given = 10m

and time = 3sec

$$\theta = \left(\frac{10}{2\pi R}\right) 2\pi$$

$$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$$

α = known

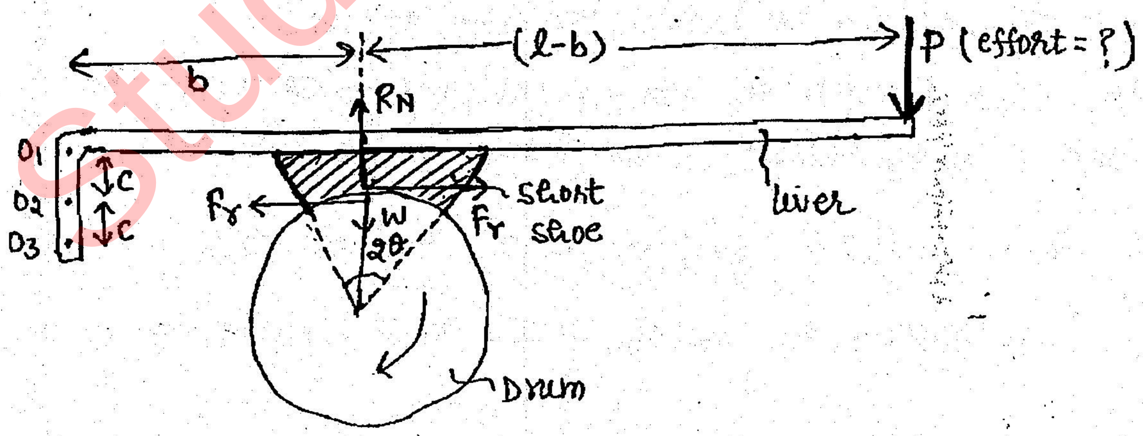
$\Downarrow$

$$\boxed{T_f = I\alpha}$$

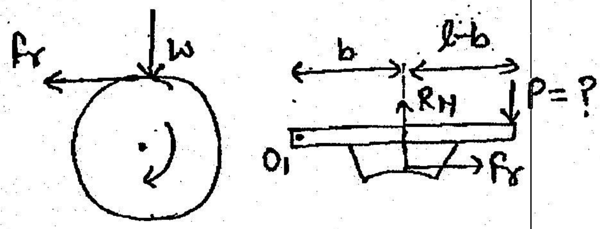
SHOE BRAKE :-

[Short shoe is rigidly attach with liver]

Short shoe ⇒ $2\theta \leq 45°$]



F.B.D



Drum :- T_f = known

$T_f = F_r \times R$, R = drum radius

$\Rightarrow$ F_r = known

$F_r = \mu R_N$

R_N = known

lever :- moment about O_1

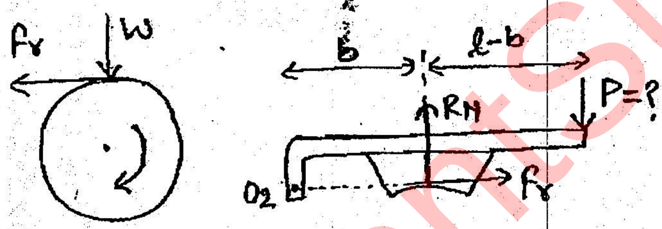
$R_N \times b + F_r \cdot c - Pl = 0$

$R_N b + \mu R_N c - Pl = 0$

$$\boxed{P = \frac{R_N(b+\mu c)}{l}}$$

effort 'P' = known

Case 2 :- (Hinged at point O_2)



Drum :-

T_f = known

$T_f = F_r \times R$, R = drum Radius

$\Rightarrow$ F_r = known

$F_r = \mu R_N$

R_N = known

lever :- moment about O_2

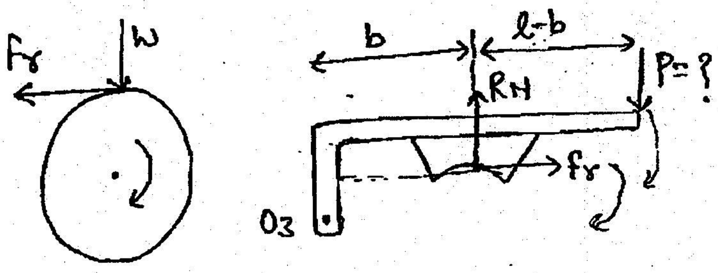
$R_N \cdot b + F_r \times 0 - Pl = 0$

$R_N b + \mu R_N \times 0 - Pl = 0$

$$\boxed{P = \frac{R_N(b)}{l}}$$

effort 'P' = known

Case 3 :- Hinged at point O_3



Drum:- T_f = known

$T_f = F_r \times R$, R = Drum Radius

F_r = known

$F_r = \mu R_N$

R_N = known , $R_N = W$

Lever :- moment about O_3

$R_N \times b - F_r(c) - Pl = 0$ self energizing brake

$R_N b - \mu R_N(c) - Pl = 0$

$$\boxed{P = \frac{R_N(b - \mu c)}{l}}$$

effort P = known

Now If $b = \mu c$

effort $P = 0$

Called as 'Self locking' OR 'Self Braking'. 'Self Energizing Brake' → Friction moment in the direction of effort

Condition :-

If

$b > \mu c \Rightarrow P = +ve \rightarrow$ controllable Braking

$b = \mu c \Rightarrow P = 0 \rightarrow$ Self locking | self Braking

$b < \mu c \Rightarrow$ effort $P = -ve \rightarrow$ Uncontrollable Braking

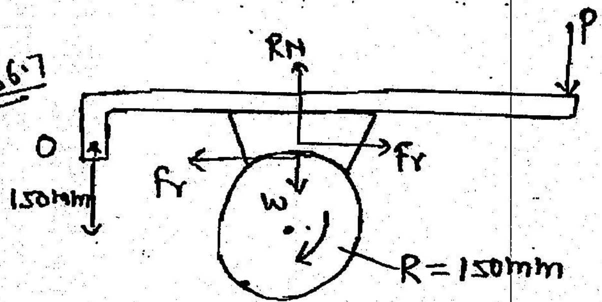
CONCLUSIONS :-

(i) A Brake is said to be a self energizing brake when moment due to friction is in same direction as moment due to effort.

(2) Self energizing brake should be designed in such a way that brake should not give self locking and uncontrollable braking.

(3) For the given configuration when drum rotate in clockwise direction fulcrum 'O_3' is the best fulcrum because it gives self energizing brake.

Ques 6.7



moment about O.

$$R_N \times 200 - P \times 600 = 0$$

$$R_N = \underline{1200\,N}$$

$$F_r = \mu R_N$$

$$= 0.25 \times 1200$$

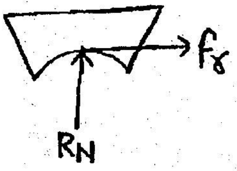
$$F_r = 300\,N$$

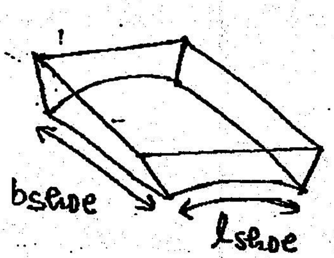
Now $T_f = F_r \times R$

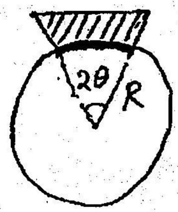
$$= 300 \times .15$$

$$\boxed{T_f = 45\,Nm}$$

DESIGN OF SHOE :- (short shoe)







$$\boxed{P_{ind} = \frac{R_N}{lb}}$$

$$\boxed{l = 2\theta \cdot R}$$

$$\therefore \quad P_{ind} = \frac{R_N}{2\theta \cdot R \cdot b}$$

Safe condition

$$P_{ind} \le P_{per}$$

$$\frac{R_N}{2\theta \cdot R \cdot b} \le P_{per}$$

$$\boxed{(R_N)_{max} = 2\theta \cdot R \cdot b \cdot P_{per}}$$

length of shoe

LONG SHOE [$2\theta > 45$]

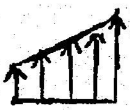
SHORT SHOE

short shoe is rigidly attach with lever

P_{ind}

LONG SHOE

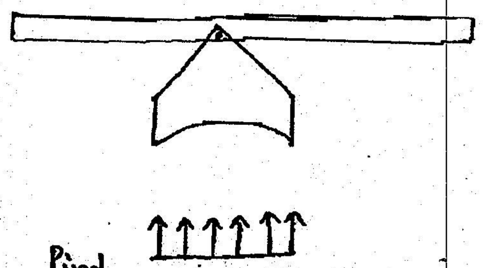
If rigidly attach with lever



more wear

Solution of more wear →

long shoe pivoted with lever to minimize wear.



Find

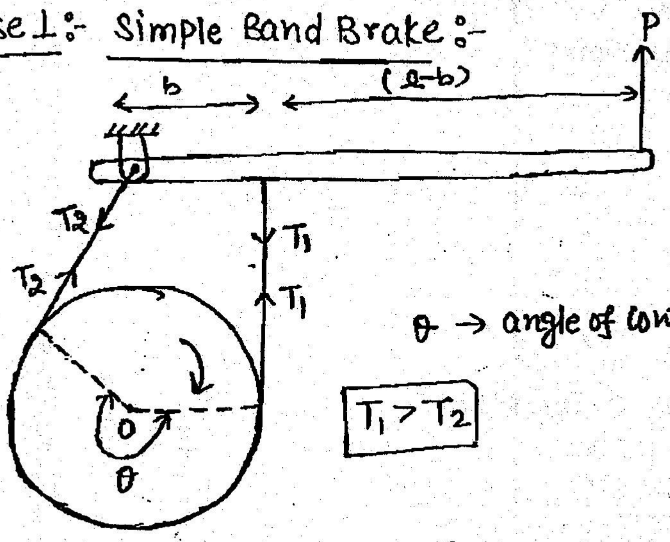
For long shoe analysis is carried by $\mu_{equivalent}$.

$$\boxed{\mu_{equ.} = \frac{4\mu\sin\theta}{2\theta + \sin 2\theta}}$$

Short shoe	Long power
⇒ Short shoe is rigidly attached with the lever.	⇒ long shoe is pivoted with the lever.
⇒ short shoe is used for low power absorbtion.	⇒ long shoe is used for high power abgorbtion.
⇒ pressure is uniformly distributed over the shoe.	⇒ Pressure is non uniformly distributed over the shoe when rigidly attached with the lever.
⇒ Analysis is carried by taking actual coefficient of friction (μ).	⇒ Analysis is carried by taking equivalent colfficient of friction ($\mu_{equ.}$)

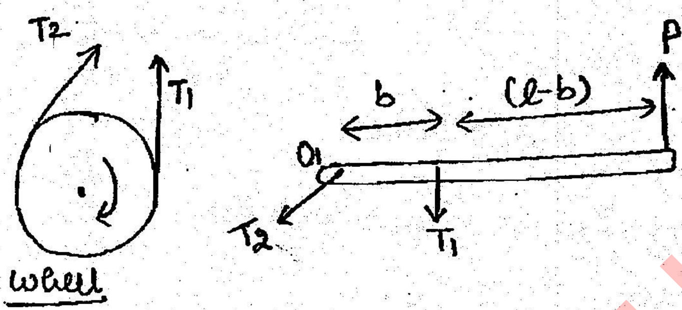
BAND BRAKE

case 1 :- Simple Band Brake :-



θ → angle of contact/overlap/angle of wrap

$\boxed{T_1 > T_2}$



heel :- T_f = known

$T_1 R - T_2 R = T_f$

$(T_1 - T_2)R = T_f$ —— (1)

ng
rge → T_1
nall → T_2

$\frac{T_1}{T_2} = e^{\mu\theta}$ —— (2)

By eq (1) & (2)

T_1, T_2 are known

$e^{\mu\theta}$ always → +ve

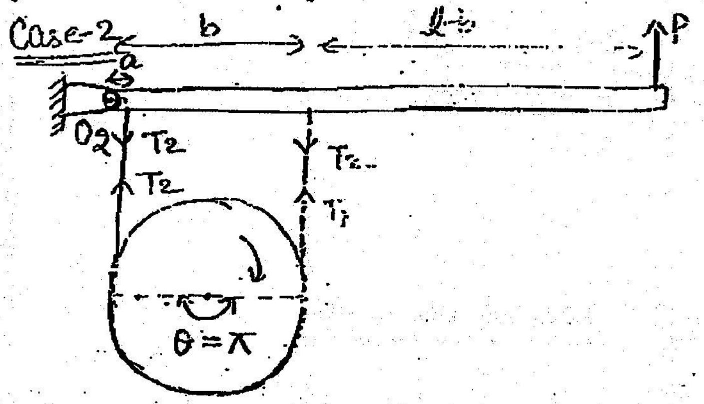
∴ T_1 → large value
T_2 → small value.

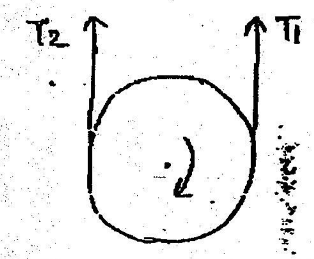
lever :- moment about O_1

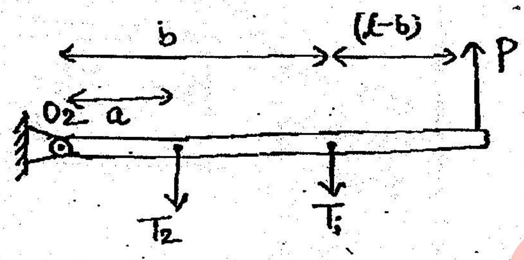
$T_1 b - P l = 0$

$$\boxed{P = \frac{T_1 b}{l}}$$

Case-2







Wheel :- T_f = known

$$T_1R - T_2R = T_f$$

$$(T_1 - T_2)R = T_f \quad \text{---(1)}$$

and

$$\frac{T_1}{T_2} = e^{\mu\theta} \quad \text{---(2)}$$

By eq(1) & eq(2)

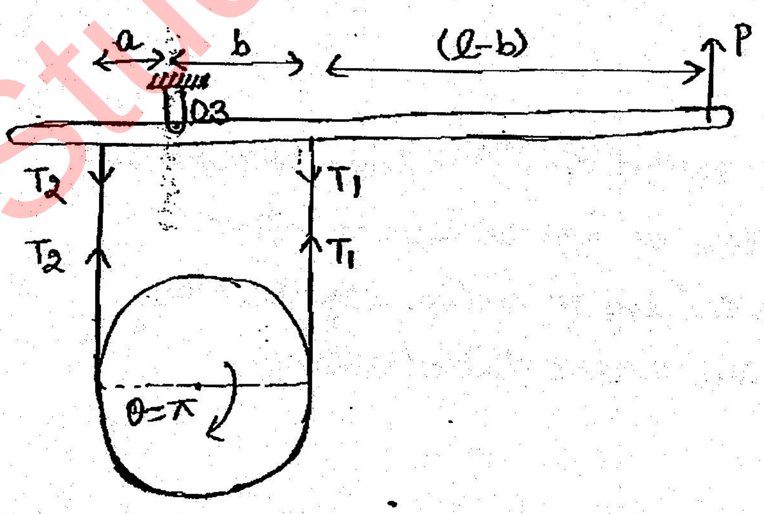
T_1 & T_2 are known

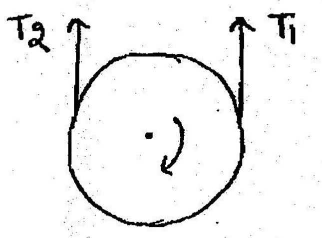
Lever :- moment about O_2

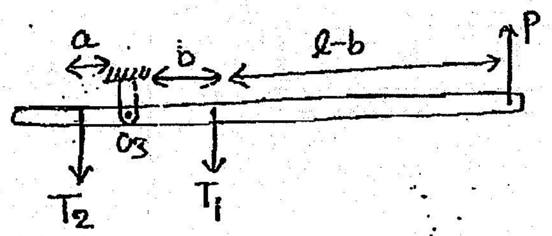
$$T_2 a + T_1 b - Pl = 0$$

$$\boxed{P = \frac{T_2 a + T_1 a}{l}}$$

Case-3 :-







wheel :- T_f = known

$T_1R - T_2R = T_f$

$(T_1 - T_2)R = T_f$ —— (1)

and $\dfrac{T_1}{T_2} = e^{\mu\theta}$ —— (2)

By eq(1) + eq(2)

T_1, T_2 are known

lever :- moment about O_3

$-T_2a + T_1b - Pl = 0$

self energizing Brake

$$\boxed{P = \frac{T_1b - T_2a}{l}}$$

Now If $T_1b = T_2a$

OR $\dfrac{T_1}{T_2} = \dfrac{a}{b}$

∴ effort $P = 0$

Self locking OR self braking] Self energizing Brake

Condition :-

If $T_1b > T_2a \Rightarrow P = +ve \longrightarrow$ Controllable Braking

$T_1b = T_2a \Rightarrow P = 0 \longrightarrow$ Self locking

$T_1b < T_2a \Rightarrow P = -ve \longrightarrow$ uncontrollable Braking

Conclusion :-

A Brake is said to be a self energizing brake when moment due to tension act in same direction as moment due to effort. Self energizing Brake should be designed in such a way that they should not give self locking and uncontrollable braking.

- For the given configuration when drum rotates in clockwise direction the fulcrum O_3 is the best fulcrum because it gives self energizing brake.

Ques 6.9

$T_f = 1000$ N-m

$R = .125$ m

$(T_1 - T_2)R = T_f$

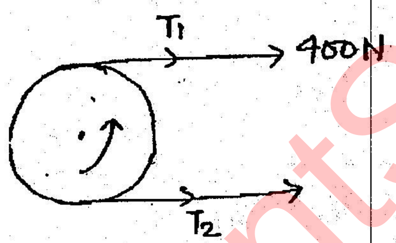
$T_1 - T_2 = 8000$ — (1)

and $\frac{T_1}{T_2} = e^{.25 \times \frac{3\pi}{2}}$ — (2)

From eq(1) & eq(2)

$\boxed{T_1 = 11.56 \text{ KN}}$

Ques 6.10



$\theta = \pi$

$T_1 = 400$N

$\frac{T_1}{T_2} = e^{\mu\theta}$

$\frac{400}{T_2} = e^{.25 \times \pi}$

$T_2 = 182.37$ N

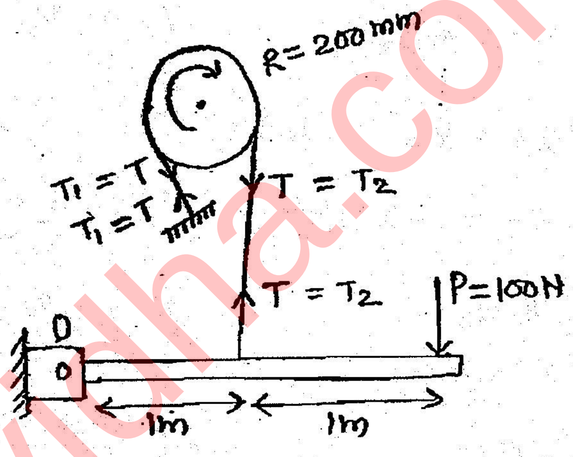
$T_f = (T_1 - T_2)R$

$T_f = (400 - 182.37)\,0.25$

$\boxed{T_f = 54.4 \text{ Nm}}$

Linked Ques 6.4 & Ques 6.5

Find the direction of Rotation also in the question.



moment about O :-

$T \times 1 = 100 \times 2$

$\boxed{T = 200 \text{ N}}$

In question Find max^m Tension.

$\therefore$ assume $T = T_2 = 200$N → because in formula T_2 is minimum. $\therefore$ T_1 max^m हो जायेगा।

$\frac{T_1}{T_2} = e^{\mu\theta}$

$\frac{T_1}{200} = e^{.5 \times \frac{3\pi}{2}}$

$\boxed{T_1 = 2110 \text{ N}}$

$T_f = (T_1 - T_2)R$

$= (2110 - 200) \times .2$

$\boxed{T_f = 382 \text{ Nm}}$

Direction → clockwise

Ques 14

$m = 1000\,kg$

$\omega_i = \cancel{200}\ 10\ rad/s$

$\omega_f = 0$

$R = .2\,m$

$t = 10\,sec$

$\omega_f = \omega_i + \alpha t$

$0 = 10 + \alpha \times 10$

$\alpha = -1\ rad/sec^2$

Now $a_T = R\alpha = 0.2 \times 1$

$a_T = 0.2\ m/s^2$

$F_r = m \times a_T$

$= 1000 \times 0.2$

$F_r = 200\,N$

Now $T_f = F_r \times R$

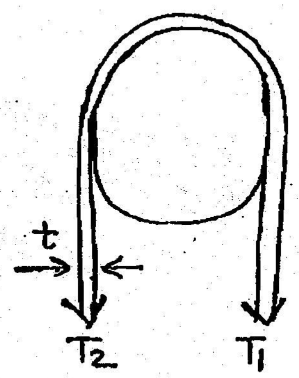
$= 200 \times 0.2$

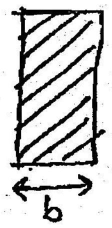
$T_f = 40\ N\text{-}m$

$(T_f)_{wheel} = \dfrac{T_f}{4} = \dfrac{40}{4}$

$\boxed{(T_f)_{wheel} = 10\ N\text{-}m}$

DESIGN OF BAND BRAKE





$T_1 > T_2$

$T_1 = T_{max}$

$(\sigma_{ind})_{max} = \dfrac{T_1}{bt}$

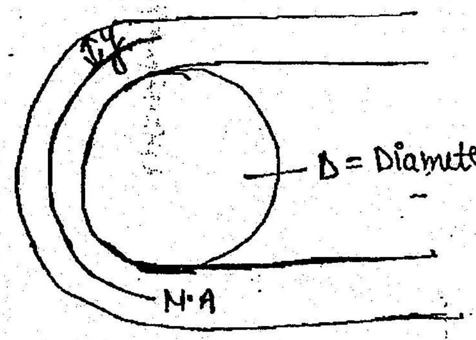
Safe Condition

$(\sigma_{ind})_{max} \le (\sigma)_{per}$

$\dfrac{T_1}{bt} \le \sigma_{per}$

Strength of Band/Belt $\boxed{T_{max} = bt\,\sigma_{per}}$

Bending in Belt | Band :-



$$\sigma_b = \frac{E}{R} \cdot y$$

$$\boxed{(\sigma_b)_{max} = \frac{E}{R} y_{max}}$$

$$\boxed{\begin{aligned} y_{max} &= \frac{t}{2} \\ R &= \frac{D}{2} + \frac{t}{2} \end{aligned}}$$

$$(\sigma_b)_{max} = \frac{E \cdot \frac{t}{2}}{\frac{D}{2} + \frac{t}{2}}$$

$$\boxed{(\sigma_b)_{max} = \frac{Et}{D+t}}$$

Safe condition

$$(\sigma_b)_{max} \le \sigma_{per}$$

$$\frac{Et}{D+t} \le \sigma_{per}$$

$$\boxed{t = \text{known}}$$