Brakes

M Arshad Zahangir Chowdhury

B.Sc. (Hons.) in Mechanical Engineering , BUET
Lecturer, Department of Mechanical & Production Engineering
Ahsanullah University of Science and Technology
Dhaka-1208, Bangladesh

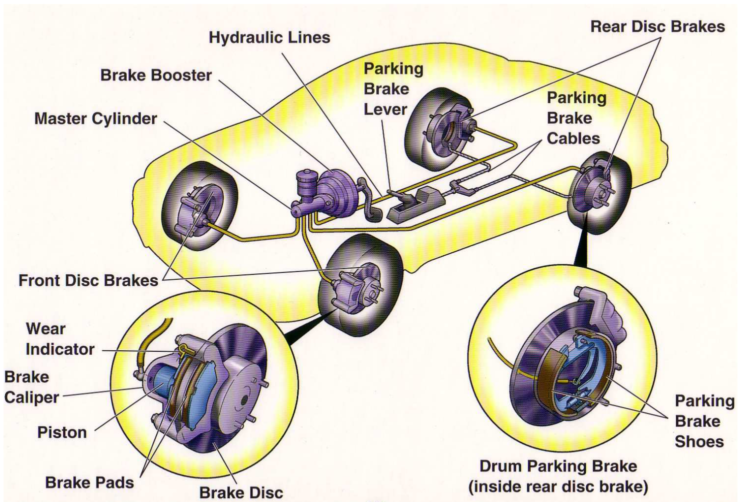
arshad.mpe@aust.edu
www.arshadzahangir.weebly.com

ME 201

Definition

- A **Brake** is a device that applies frictional resistance to a moving machine member in order to stop or retard the motion of the machine.
- To perform this function , a brake either
  1. absorbs kinetic energy of the moving member or
  2. gives up potential energy by objects being lowered by hoists,elevators etc.
  3. Contact/lap angle
  4. Operating conditions
- The absorbed energy is dissipated in the form of heat to surrounding air (or circulating water/coolant). This prevents excessive heating of break lining.

Example



Example

Single Block Brake/ Shoe Brake

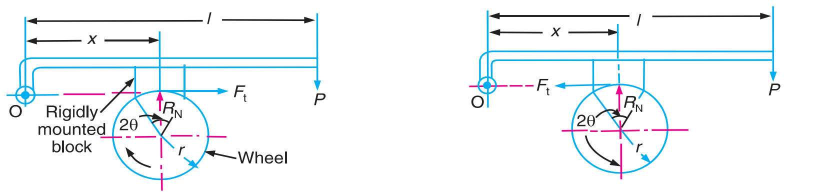
Derivation of expression for brake torque(T_B)

- Consider a single block brake/shoe brake as shown in figure.
- It consists of a block/shoe that presses against the rim of a revolving brake wheel drum.
- The The block is made of a softer material than the rim of the wheel.
- The friction between the block & the wheel causes a tangential braking force to act on the wheel that retards the rotation of the wheel.
- The block is pressed against the wheel by applying a force to one end of the lever to which the block is rigidly fixed. The other end of the lever is pivoted/hinged at fixed fulcrum O.
- Three cases are considered for the brake.

Nomenclature
P = Applied force
R_N = Normal Reaction Force
r = Wheel radius
2θ = Contact Angle of the block surface
μ = Friction coefficient
F_t = Tangential braking force or friction force acting at the contact of the block & wheel
If contact angle is less than 60^o then $F_t = \mu R_N$ = Friction force

Case I

The line of action of tangential braking force (F_t) passes through fulcrum (O) of the lever and the braking wheel rotates clockwise and counterclockwise as shown below.



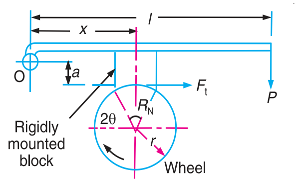
(a) Clockwise rotation of brake wheel (b) Anticlockwise rotation of brake wheel.
Single block brake. Line of action of tangential force passes through the fulcrum of the lever.

For equilibrium,
$\sum M = 0$
$R_N x - Pl = 0$
$R_N = \frac{Pl}{x}$

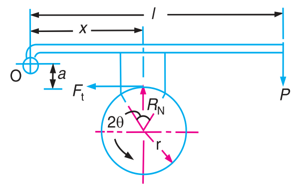
$\therefore$ Braking Torque $T_B = F_t r$
$\Rightarrow T_B = \mu R_N r$
$\Rightarrow \boxed{T_B = \frac{\mu Plr}{x}}$
The expression is valid for both CW and CCW rotation of wheel.

Case II

The line of action of tangential braking force (F_t) passes through a distance 'a' below fulcrum (O) of the lever as shown below.



(a) Clockwise rotation of brake wheel.



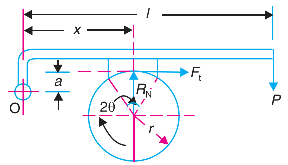
(b) Anticlockwise rotation of brake wheel.

For clockwise rotation
Equilibrium dictates, $\sum M = 0$
$\Rightarrow R_N x - Pl + F_t a = 0$
$R_N = \frac{Pl}{x + \mu a}$
$\therefore$ Braking Torque $T_B = F_t r = \mu R_N r$
$\Rightarrow \boxed{T_B = \frac{\mu Plr}{x + \mu a}}$

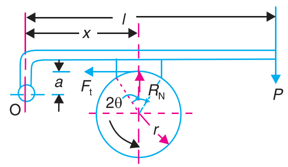
For counterclockwise rotation
Equilibrium dictates, $\sum M = 0$
$\Rightarrow R_N x - Pl - F_t a = 0$
$R_N = \frac{Pl}{x - \mu a}$
$\therefore$ Braking Torque $T_B = F_t r = \mu R_N r$
$\Rightarrow \boxed{T_B = \frac{\mu Plr}{x - \mu a}}$

Case III

The line of action of tangential braking force (F_t) passes through a distance 'a' above fulcrum (O) of the lever as shown below.



(a) Clockwise rotation of brake wheel.



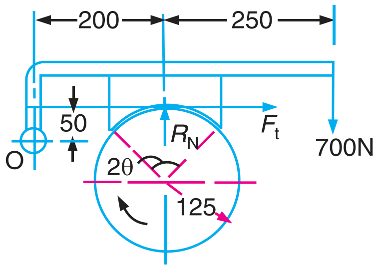
(b) Anticlockwise rotation of brake wheel.

For clockwise rotation
Equilibrium dictates, $\sum M = 0$
$\Rightarrow R_N x - Pl - F_t a = 0$
$R_N = \frac{Pl}{x - \mu a}$
$\therefore$ Braking Torque $T_B = F_t r = \mu R_N r$
$\Rightarrow \boxed{T_B = \frac{\mu Plr}{x - \mu a}}$

For counterclockwise rotation
Equilibrium dictates, $\sum M = 0$
$\Rightarrow R_N x + Pl - F_t a = 0$
$R_N = \frac{Pl}{x + \mu a}$
$\therefore$ Braking Torque $T_B = F_t r = \mu R_N r$
$\Rightarrow \boxed{T_B = \frac{\mu Plr}{x + \mu a}}$

Case III

A single block brake is shown in figure. Diameter of the drum is 250mm & angle of contact is 90^o. If 700 N force is applied at the end of a lever and coefficient of friction between the drum and the lining is 0.35. Determine the brake torque transmitted by the block.



All dimensions in mm.

$\because$ The angle of contact is greater than 60^o, $\therefore$ equivalent coefficient friction,

$$\mu_e = \frac{4\mu sin\theta}{2\theta + sin2\theta} = \frac{4 \times 0.35 \times sin45^o}{\frac{\pi}{2} + sin90^o} = 0.385$$

$\therefore$ Braking Torque $T_B = \frac{\mu_e Plr}{x - \mu a}$

$\Rightarrow$ Braking Torque

$$T_B = \frac{0.385 \times 700 \times 0.45 \times 0.125}{0.2 - 0.385 \times 0.050}$$

$\Rightarrow T_B = 83.86$ Nm (Ans.)

Solution:

Here, d =250 mm $\therefore$ r = 125 mm ; a = 50 mm

$2\theta = 90^o = \frac{\pi}{2}$ rad

P = 700 N ; $\mu = 0.35$