7. CLUTCH

Clutch is a machine element [intermediate] which is used to transmission power from driving shaft [power source] to driven shaft [gear box] at the will of operator.

TYPES OF CLUTCHES					
Friction Clutch				**Positive Clutch**	
Single Plate	Multi Plate	Cone Clutch	Centrifugal Clutch	Square jaw Clutch	Spiral jaw Clutch

Assumptions: Pressure over the friction lining is to be constant (p).

dN = p 2πr dr, df = μ dN, dT = r df $N = \int_{r_i}^{r_0} p\, 2\pi r\, dr$ $T = \int_{r_i}^{r_0} \mu\, p\, 2\pi r^2\, dr$	W = axial load required for engagement, N = Normal reaction between the contacting surface, r_i = inner radius of friction lining, r_o = outer radius of friction lining, T = Total frictional torque = Total torque transmitted.

UNIFORM PRESSURE THEORY	UNIFORM WEAR THEORY (Considered for design)
Condition: Pressure in radial direction (p)	**Condition:** Wear = Constant
p = Constant	Here, Wear ∝ p, V, V = velocity = r ω Hence, pr = constant (rectangular hyperbola)
N = Uniform pressure * Area of friction lining = p π $(r_o^2 - r_i^2)$	$N = C\, 2\pi\, (r_o - r_i)$ Where, $p_{max} r_i = p_{min} r_o = C$
T = μN r_p= μW r_p $equivalent\ radius, r_p = \frac{2}{3}\left[\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right]$	T = μN r_w= μW r_w $equivalent\ radius, r_w = r_{mean} = \frac{r_o + r_i}{2}$
Rectangular shape of lining: Brand new condition	Variation of lining thickness: Operating condition
$T_p > T_W$	

SINGLE PLATE CLUTCH:

Case – I: Single Plate Clutch Effective On One Side	Case – I: Single Plate Clutch Effective On Both Side
Friction plate is either attached to driving shaft or driven shaft.	Friction plate is not attached to neither driving shaft nor driven shaft.
No. of pair of contacting surface (n) = 1	No. of pair of contacting surface (n) = 2

MULTI PLATE CLUTCH:

No. of pair of contacting surface (n) = No. of plates – 1 = $(\sum_i n_i) - 1$

Total normal reaction N = nW **and** T = μN r = nμW r (Where, n is positive integer (**real**) number)

CONE CLUTCH:

dN = p [2πr / (sin ∝)] dr, df = μ dN, dT = r df $b = \frac{r_o - r_i}{\sin \propto}$	2∝ = Cone angle, ∝ = Semi-Cone angle, b = face width of friction lining, W = axial load required for engagement, N = Normal reaction between the contacting surface,
UNIFORM PRESSURE THEORY	**UNIFORM WEAR THEORY (Considered for design)**
N = p π $(r_o^2 - r_i^2)$/ sin ∝	$N = C\, 2\pi\, (r_o - r_i)/\sin \propto$
$\boldsymbol{N = W/\sin \propto}$	
T = μN r_p= μW r_p/ sin ∝	T = μN r_w= μW r_w/ sin ∝

Axial load required for engagement (w_e): $w_e = N \sin\alpha + f' \cos\alpha = N\,[\sin\alpha + \mu' \cos\alpha] = W[1 + \mu' \cot\alpha]$

Axial load required for dis-engagement (w_e): $w_d = N \sin\alpha - f' \cos\alpha = N\,[\sin\alpha - \mu' \cos\alpha] = W[1 - \mu' \cot\alpha]$

What is f' direction?

CENTRIFUGAL CLUTCH:

$F_{S1} = F_{C1} = mr_g\omega_1^2 = F_{S2}$ $R = mr_g(\omega_2^2 - \omega_1^2)$ $T_{each\ shoe} = \mu R\ r_d$ $T = nT_{each\ shoe}$ n = Number of shoes,	N_1 = Speed at which shoe is about to contact hub, N_2 = Speed at which toque is transmitted, r_g = distance between C.G. of shoe and centre of rotation, r_d = distance between centre of rotating shaft and hub surface, m = mass of each shoe, T = Total torque transmitted,
length of shoe l = θ r_d Radial Pressure (P) = R/wl	θ = Angle subtended by contacting surface of shoe at centre, w = width of shoe.

CVT (CONTINOUS VARIABLE TRANSMISSION)

POSITIVE/JAW CLUTCH:

No slip conditions. Hence its positive clutch.
no heat generation, synchronous speed, Maximum torque transmission.
Teeth's/ Jaws are made in form of groove for interlocking action.
Shock is observed when it's Engauge in running condition.

Square Jaw Clutch:

Jaws are made of square shape. So, both direction power transition is possible. Can't Engauge in running condition.

Spiral jaw clutch:

Jaws are made of spiral shape. Only one direction power transition is possible. And disengagement is possible in running condition.
Applications: Rolling mills, Presses.