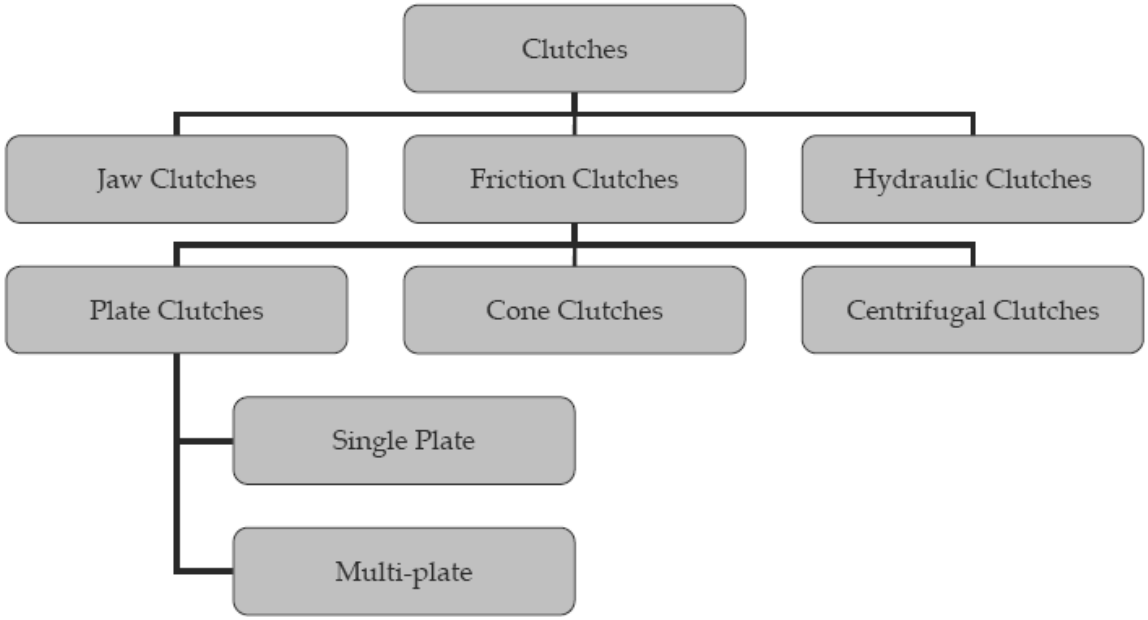
Lecture note/Handout for CLUTCH

After reading the lesson, the students should learn:
• Different types of clutches and their operating principles
• Design procedure of different types of clutches

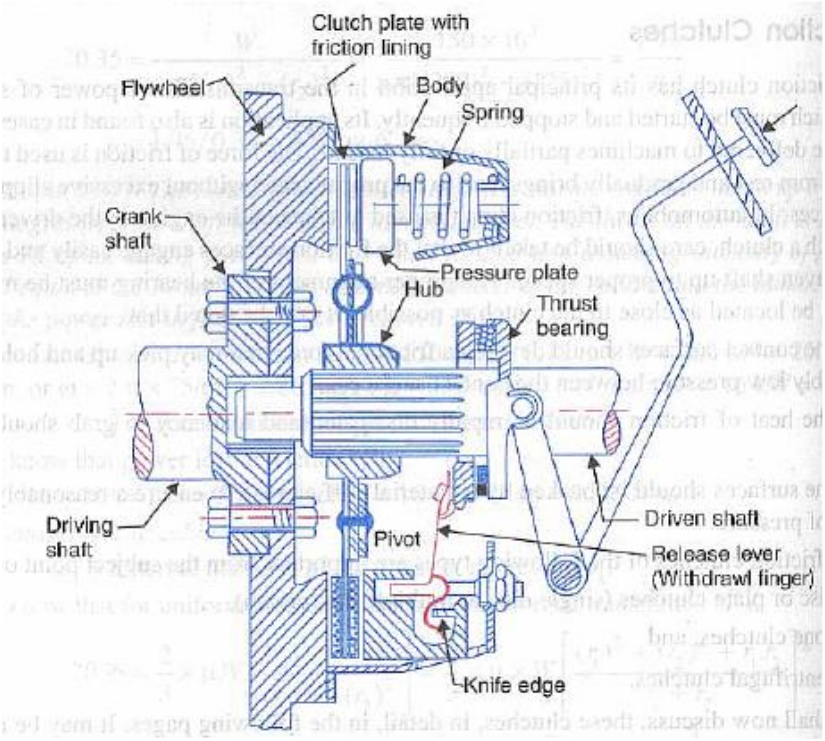
Cutch is a device to connect driving and driven shafts of a machine, where the driven shaft can be disconnected almost instantaneously from the driving shaft as desired by the operator or driver.



The friction type of clutches work on the basis of the frictional forces developed between the surfaces in contact. Friction clutches are usually preferred over the jaw clutches due to their better performance characteristics, shock and impact free engagement and easy operation. In the axial type of clutches an axial movement of the clutch parts attached to the driven shaft achieves the engagement or disengagement of the clutch.

Whereas in the radial type of clutches the contact pressure is applied in a direction perpendicular to the shaft axis. Plate or disc and conical type of clutches are of the axial type and tyre pneumatic,centrifugal, over-running or free-wheel, block,expanding ring and band clutches are of the radial type. The plate type of clutches may be either of the single plate type or multiplate friction clutches. Multiplate friction clutches are generally used in small automobiles, like scooters and three wheelers whereas single plate clutches are used in heavy vehicles like trucks, buses etc. Multiplate clutches are suitable for working in oil. Oil acts as a cushion and energy released by heat is carried away by oil.

Single Plate Clutch



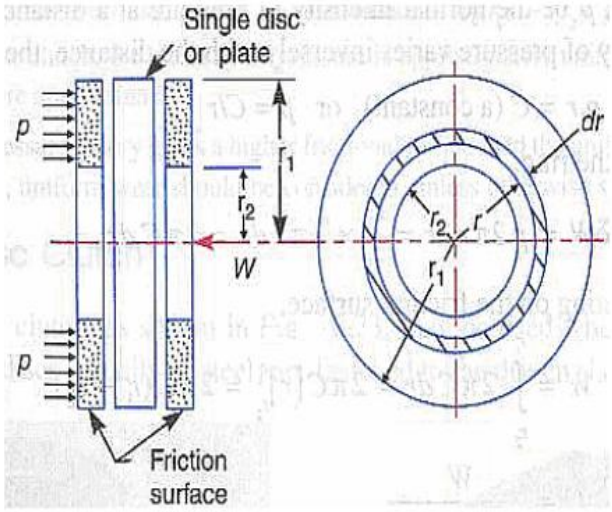


Plate clutch

Multi plate Clutch

The total frictional torque T :

$$T = n\mu WR$$

R – mean radius

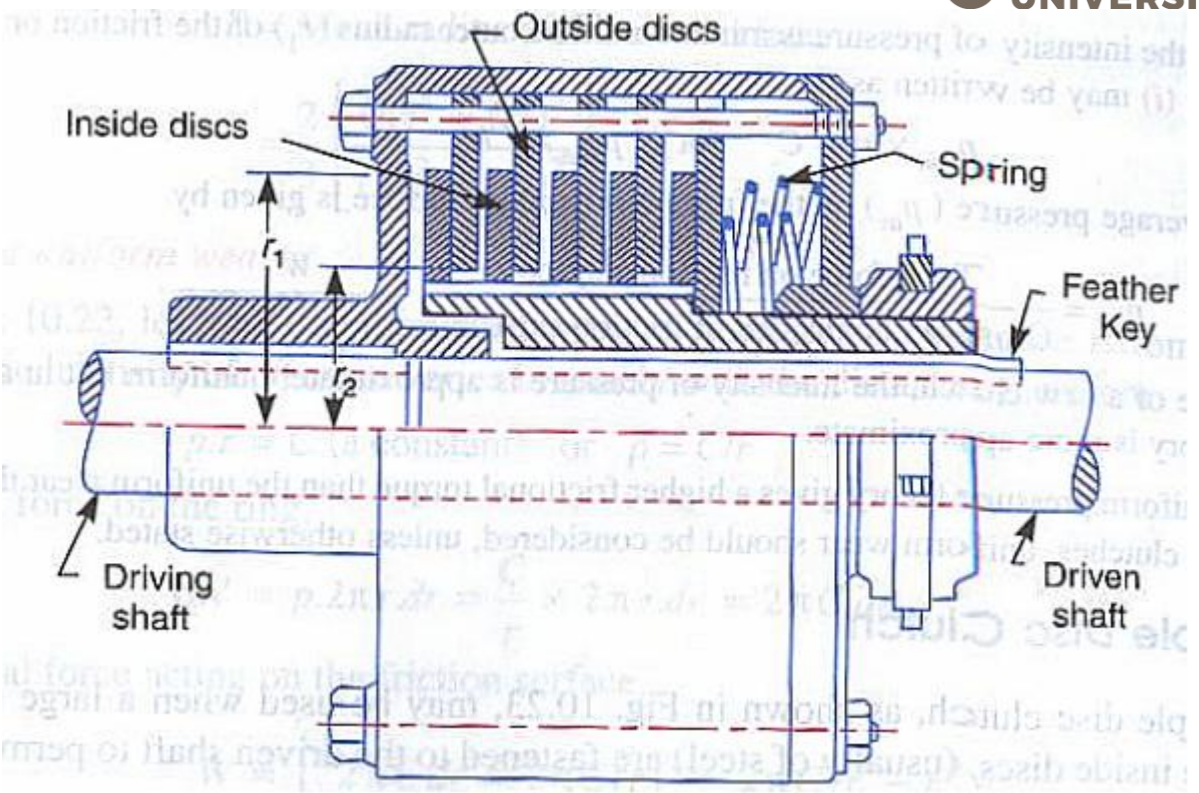
n– number of friction surfaces

- For uniform pressure (for new clutches)

$$R = \frac{2}{3}\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]$$

- For uniform wear (for old clutches)

$$R = \frac{[r_1 + r_2]}{2}$$



The total frictional torque T :

$$T = n\mu WR$$

R – mean radius

n– number of friction surfaces

$n = n_1 + n_2 - 1$

where;

n_1 – number of discs on the driving shaft

n_2 – number of discs on the driven shaft

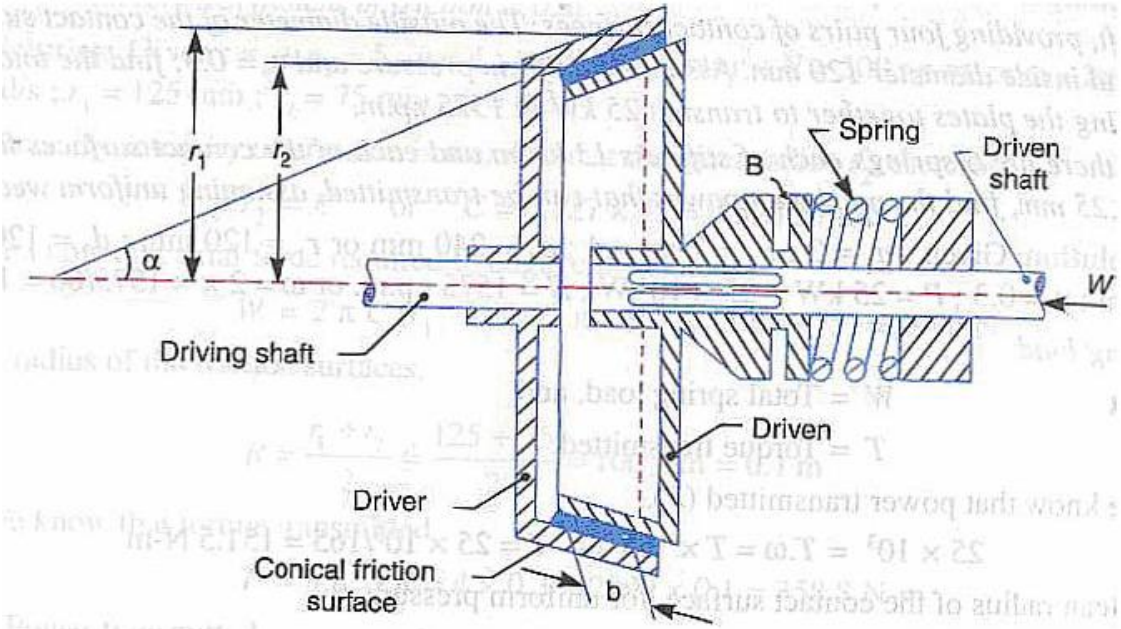
- For uniform pressure (for new clutches)

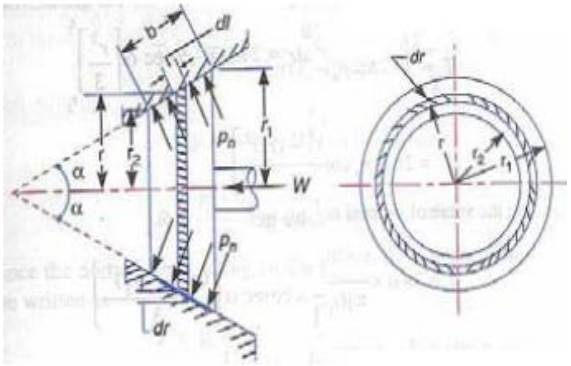
$$R = \frac{2}{3}\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]$$

- For uniform wear (for old clutches)

$$R = \frac{[r_1 + r_2]}{2}$$

Cone clutch





Cone clutch

dl = *drcoseca* and p_n are normal to the friction surface

Centrifugal Clutch

The total frictional torque T :

$$T = \mu WR$$

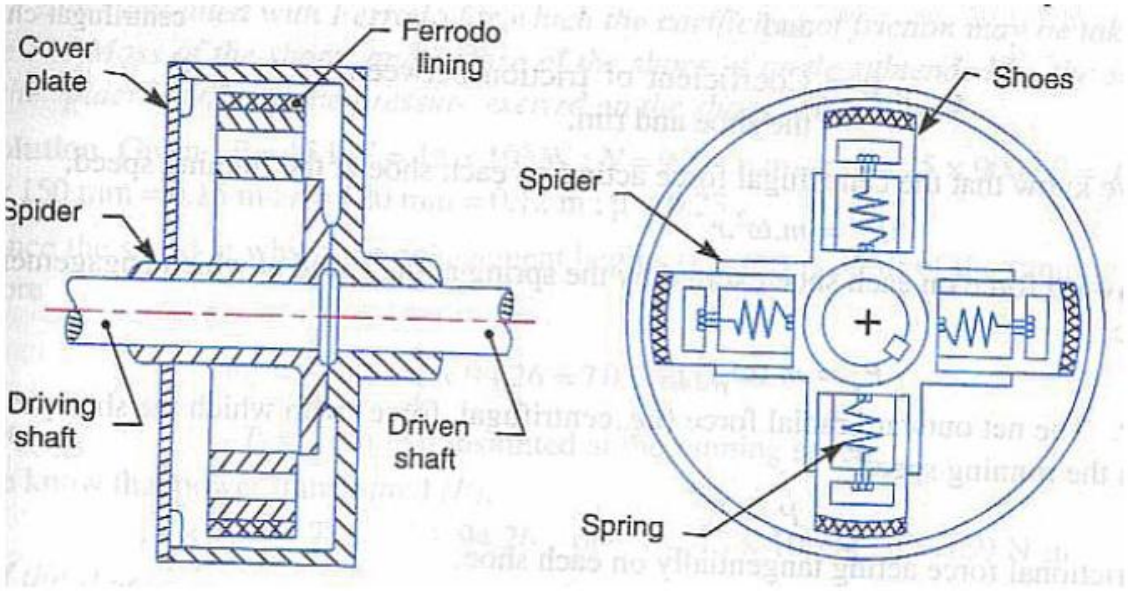
R – mean radius

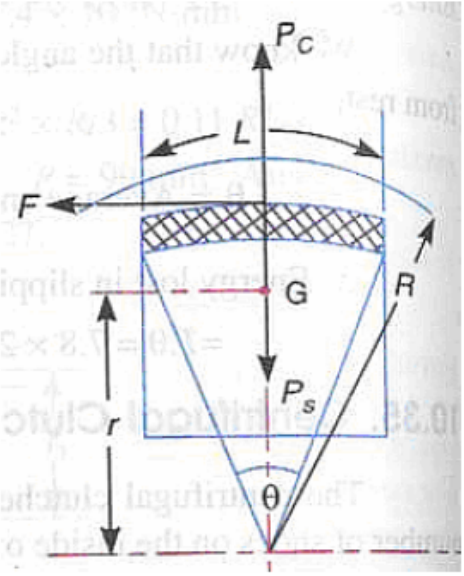
For uniform pressure (for new clutches)

$$R = \frac{2}{3}\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]\cos ec\alpha$$

- For uniform wear (for old clutches)

$$R = \frac{[r_1 + r_2]}{2}\cos ec\alpha$$





m – mass of each shoe
n – number of shoes
r - Distance to the centre of gravity of the shoe from the centre of the spider
R – inside radius of pulley rim
ω – angular speed of the pulley in rad/s
ω1 – angular speed at the beginning of the engagement
μ- coefficient of friction

The total frictional torque

$$T = \mu(P_c - P_s)Rn$$

$$P_c = mr\omega^2$$

$$P_s = mr\omega_1^2$$

Lecture note/Handout of BRAKE

After reading the lesson the students should learn:
• Different types of shoe brakes and their operating principles
• Design procedure of different shoe brakes
• Different types of band brakes
• Design of band brakes
• Design of disc brakes
• Properties of friction materials

Types of brakes

Brakes are devices that dissipate kinetic energy of the moving parts of a machine. In mechanical brakes the dissipation is achieved through sliding friction between a stationary object and a rotating part. Depending upon the direction of application of braking force, the mechanical brakes are primarily of three types

- Shoe or block brakes – braking force applied radially

- Band brakes – braking force applied tangentially.
- Disc brake – braking force applied axially.

Shoe or block brake

In a shoe brake the rotating drum is brought in contact with the shoe by suitable force. The contacting surface of the shoe is coated with friction material. Different types of shoe brakes are used, viz., single shoe brake, double shoe brake, internal expanding brake, external expanding brake.

Double shoe brake

Since in a single shoe brake normal force introduces transverse loading on the shaft on which the brake drum is mounted two shoes are often used to provide braking torque. The opposite forces on two shoes minimize the transverse loading. The analysis of the double shoe brake is very similar to the single shoe brake.

External expanding shoe brake

An external expanding shoe brake consists of two symmetrically placed shoes having inner surfaces coated with frictional lining. Each shoe can rotate about respective fulcrum. When the shoes are engaged, non-uniform pressure develops between the friction lining and the drum. The pressure is assumed to be proportional to wear which is in turn proportional to the perpendicular distance from pivoting point. A simple geometrical consideration reveals that this distance is proportional to sine of the angle between the line joining the pivot and the center of the drum and the line joining the center and the chosen point.

Internal expanding shoe brake

Here the brake shoes are engaged with the internal surface of the drum. The analysis runs in the similar fashion as that of an external shoe brake.

Band brakes:

The operating principle of this type of brake is the following. A flexible band of leather or rope or steel with friction lining is wound round a drum. Frictional torque is generated when tension is applied to the band. It is known that the tensions in the two ends of the band are unequal because of friction.

Band and block brakes:

Sometimes instead of applying continuous friction lining along the band, blocks of wood or other frictional materials are inserted between the band and the drum.

Disk Brake:

In this type of brake two friction pads are pressed axially against a rotating disc to dissipate kinetic energy. The working principle is very similar to friction clutch. When the pads are new the pressure distribution at pad-disc interface is uniform,

Friction materials and their properties.

The most important member in a mechanical brake is the friction material. A good friction material is required to possess the following properties:

- High and reproducible coefficient of friction.
- Imperviousness to environmental conditions.
- Ability to withstand high temperature (thermal stability)
- High wear resistance.
- Flexibility and conformability to any surface.

Some common friction materials are woven cotton lining, woven asbestos lining, molded asbestos lining, molded asbestos pad, Sintered metal pads etc

Text books

1) V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Co.

2) Design of Machine Elements, M.F.Spotts, T.E.Shoup, L.E.Hornberger, S.R.Jayaram and C.V. Venkatesh, Pearson Education.
3) Josheph Shighly, Mechanical Engineering Design, Tata McGraw Hill Book Co.
4) Farazdak Haideri, Machine Design - Volume 1, 2, Nirali Prakashan.
5) Dr. S.S. Wadhwa, Machine Design, Dhanpat rai & Co.
6) P.C.Sharma & Aggarwal, Machine Design, Katariya & Sons.

Reference Books

1) Joseph Shigley, Charles Mischke, Thomas Brown, Standard Handbook of Machine Design, McGraw-Hill Publishing Co .
2) Norton and Norton, Machine Design: An Integrated Approach, Pearson Publication.