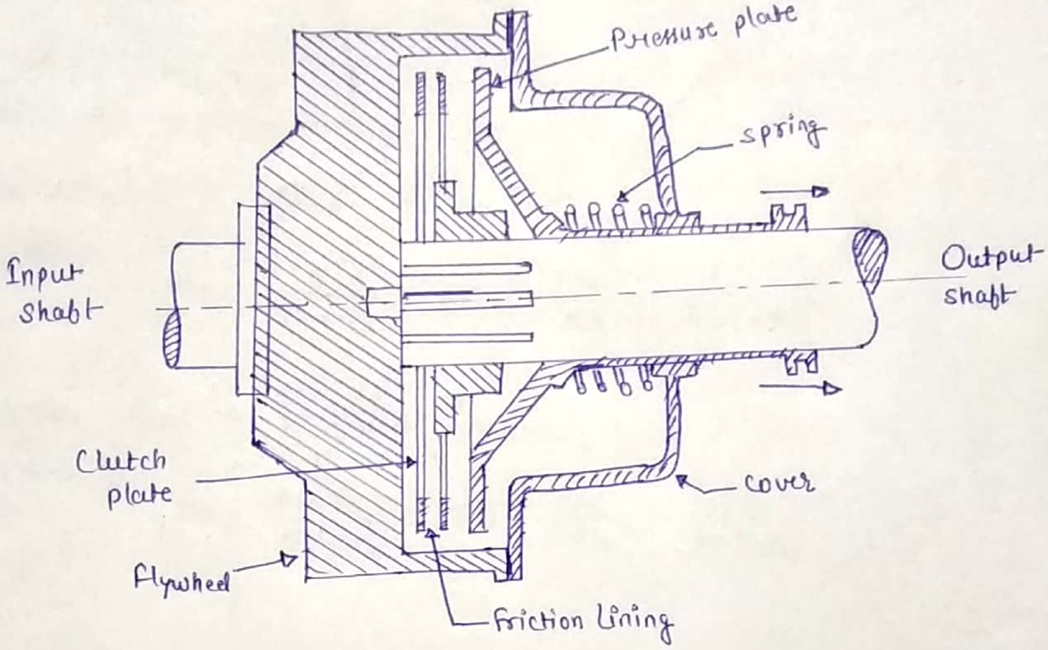
Friction - Clutches

A clutch is a device used to transmit the rotary motion of one shaft to another when desired. The axes of the two shafts are coincident.

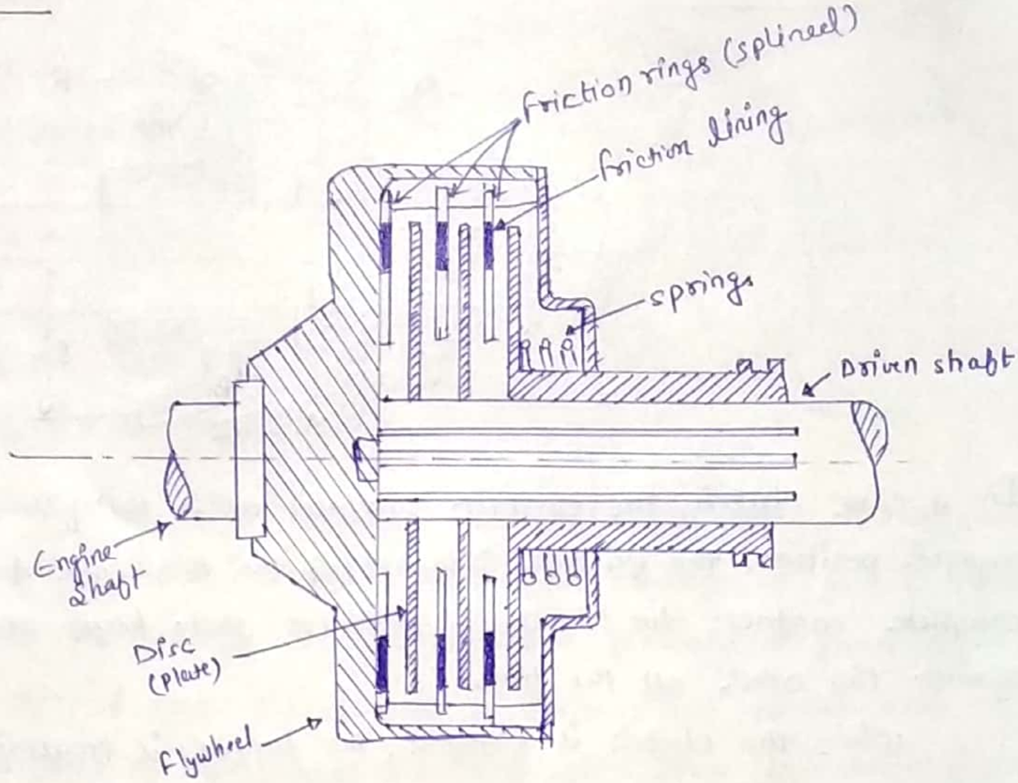
(1.) Disc Clutch (Single - plate Clutch) →



A disc cluth consists of a clutch plate attached to a splined hub which is free to slide axially on splines cut on the driven shaft. The clutch plate is made of steel and has a ring of friction linning on each side. The engine shaft supports a rigidly fixed ~~also~~ flywheel.

A spring loaded pressure plate presses the clutch plate firmly against the flywheel when the clutch is engaged. When disengaged, the spring press against a cover attached to the flywheel. Thus, both the flywheel & the pressure plate rotate with the input shaft. The movement of the clutch pedal is transferred to the pressure plate through a thrust Bearing.

(2) Multi-plate Clutch→



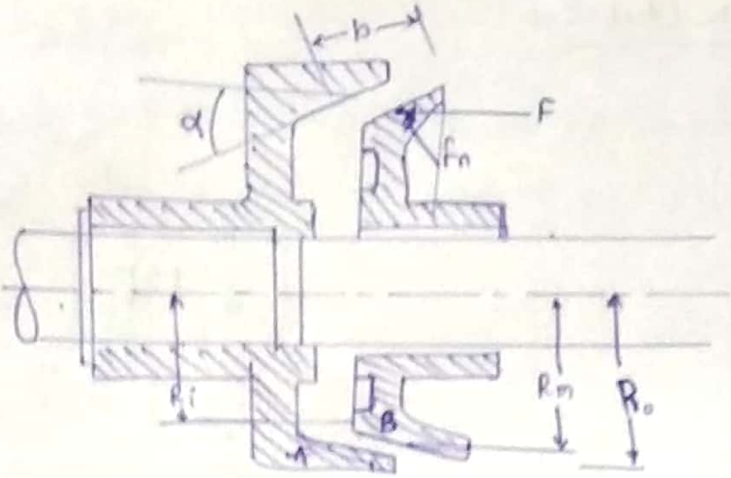
In a multi-plate clutch, the number of frictional linings and the metal plates is increased which increases the capacity of the clutch to transmit torque.

The friction rings are splined on their outer circumference & engage with corresponding splines on the flywheel. They are free to slide axially. The friction material thus, rotates with the flywheel & the engine shaft.

The driven shaft also supports the discs on the splines which rotates with the driven shaft and can slide axially. If the actuating force on the pedal is removed, a spring presses the discs into contact with the friction rings & the torque is transmitted b/w the engine shaft & the driven shabt.

If n is total no. of plates both on the driving & the driven members, the no. of active surfaces will be n-1.

(3) Cone Clutch →



In a cone clutch, the contact surfaces are in the form of cones. In the engaged position, the friction surfaces of the two cone A & B are in complete contact due to spring pressure that keeps one cone pressed against the other all the time.

When the clutch is engaged, the torque is transmitted from the driving shaft to the driven shaft through the flywheel & the friction cones. For disengaging the clutch, the cone B is pulled back through a lever system against the force of the spring.

The advantage of a cone clutch is that the normal force on the contact surface is increased. If F is the axial force, F_n is the normal force & α the semi-cone angle of the clutch then for a conical collar with uniform wear theory,

$$F_n = \frac{F}{\sin\alpha} = \frac{2\pi r p (R_o - R_i)}{\sin\alpha}$$

$\{ F = 2\pi r p (R_o - R_i) \}$

$\{ \sin\alpha = \frac{R_o - R_i}{b} \}$

$$\boxed{F_n = 2\pi p \cdot r \cdot b}$$

b → width of cone face.

$p \cdot r$ = constant.

p → Normal pressure at radius.

$$T = \frac{\mu F}{2\sin\alpha}(R_o + R_i)$$

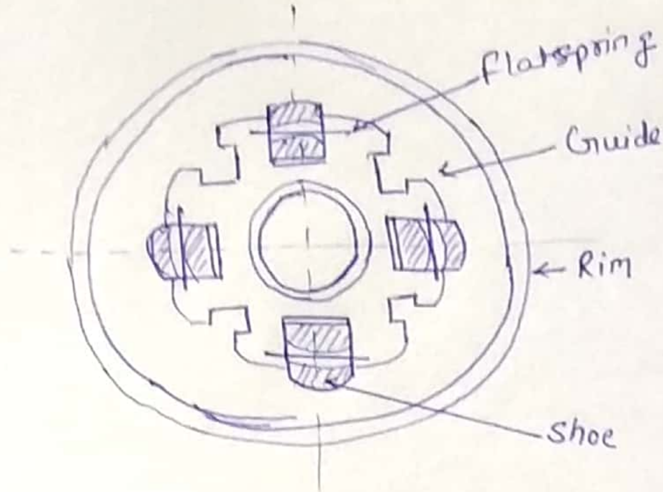
$$= \frac{\mu F_n \sin\alpha}{\sin\alpha} \cdot \frac{(R_o + R_i)}{2}$$

$\sin\alpha$ (neglect)

$$\boxed{T = \mu F_n R_m}$$

$\{ R_m$ = Mean radius of clutch $= \frac{R_o + R_i}{2} \}$

(4) Centrifugal Clutch :-



Centrifugal clutches are being increasingly used in automobiles & machines.

A centrifugal clutch has a driving members consisting of four sliding blocks. These blocks are kept in position by means of flat springs provided for the purpose. As the speed of shaft increases, the centrifugal force on the shoes increases. When the centrifugal force exceeds the resisting force of the springs, the shoes move forward & press against the inside of the rim & thus the torque is transmitted to the rim. The outer surfaces of the shoes are lined with some friction material.

Let,
- m = mass of each shoe
- R = inner radius of the pulley rim
- r = distance of centre of mass of each shoe from the shaft axis.
- n = no. of shoes
- ω = normal speed of the shaft in rad/s
- ω' = speed at which the shoe moves forward.
- μ = Coefficient of friction b/w the shoe & the rim.

Centrifugal force exerted by each shoe at the time of engagement $= m r \omega'^2$

Centrifugal force exerted by each shoe at normal speed $= m r \omega^2$

Net normal force exerted by each shoe on the rim $= m r \omega^2 - m r \omega'^2$

$= m r (\omega^2 - \omega'^2)$

Frictional force acting tangentially on each shoe $= \mu . m r (\omega^2 - \omega'^2)$

Frictional Torque acting on each shoes $= \mu . m r (\omega^2 - \omega'^2) . R$

Total frictional acting $= \mu . m r . (\omega^2 - \omega'^2) . R . n$

If p is the maximum pressure intensity exerted on the shoe then

$$m r (\omega^2 - \omega'^2) = p . l . b .$$

l & b → contact length & width of each shoe.