Clutches (Theory and Numerical)

- Uniform Pressure and Uniform Wear Theory
- Pivot and collar friction
- Plate clutches
- Cone clutches
- Centrifugal clutch

Uniform Pressure Theory

In a new bearing, the contact between the shaft & bearing may be good over the whole surface. So pressure over the rubbing surfaces is uniformly distributed.

Here,

$$p = \text{constant.}$$

Uniform Wear Theory

When the bearing becomes old, all parts of the rubbing surfaces will not move with the same velocity. Velocity of rubbing increases with distance from the axis of bearing. Hence, wear may be different at different radii.

$$\text{Rate of wear} \propto p$$

$$\text{Rate of wear} \propto v$$

Uniform wear theory

But, $v \propto r$ ………….. ($v = r\omega$)

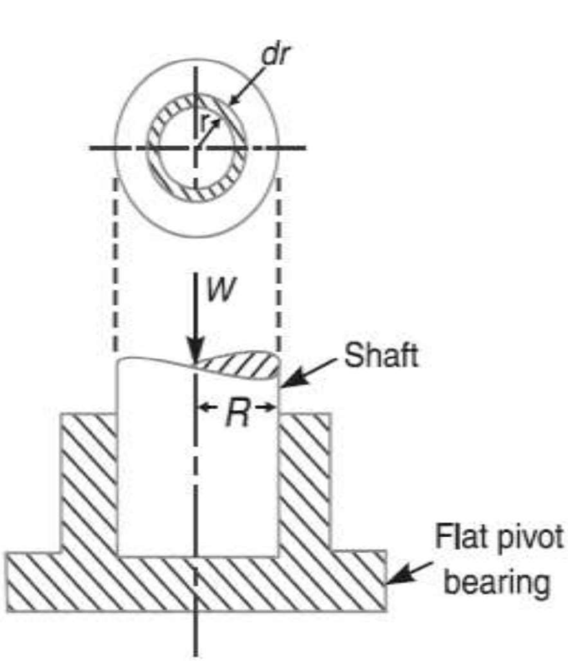
So,

Rate of wear $\propto p.v$

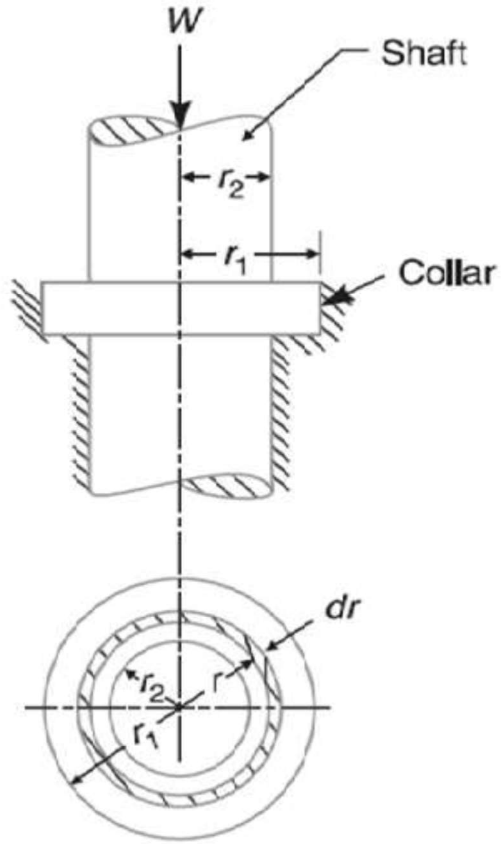
Rate of wear $\propto p.r$ ……….(as $v \propto r$)

pr = constant (c)

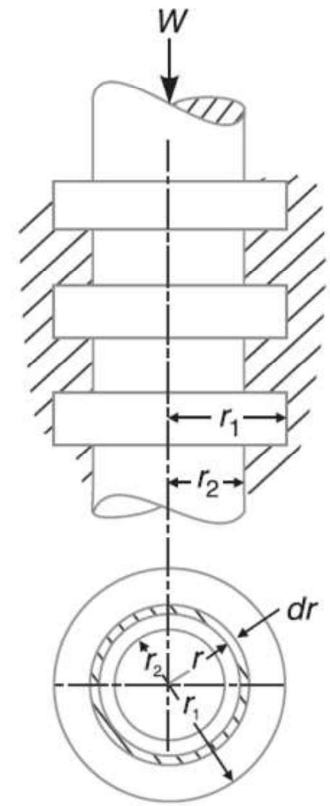
$P(max) \times r(min) = P(min) \times r(max) = c$



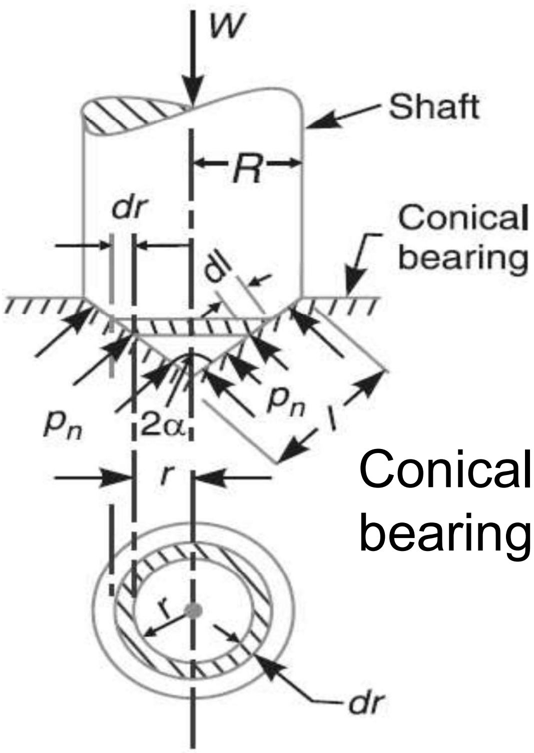
Flat Pivot Bearing



Collar Flat Pivot Bearing

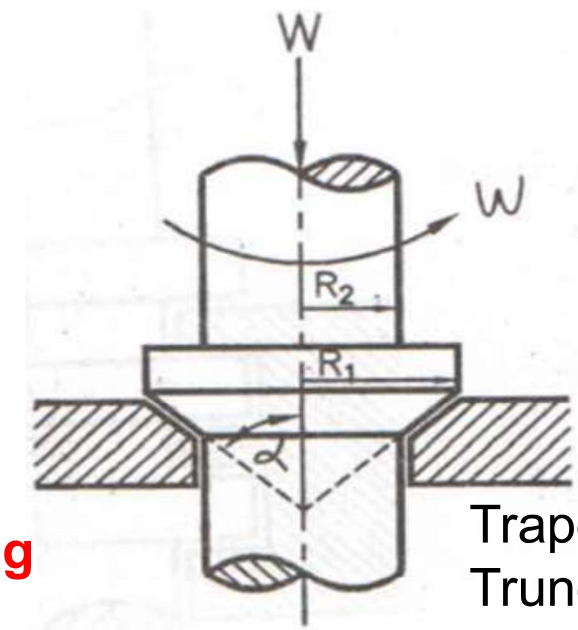


Multiple Collars



Conical pivot bearing

Pivot Bearing



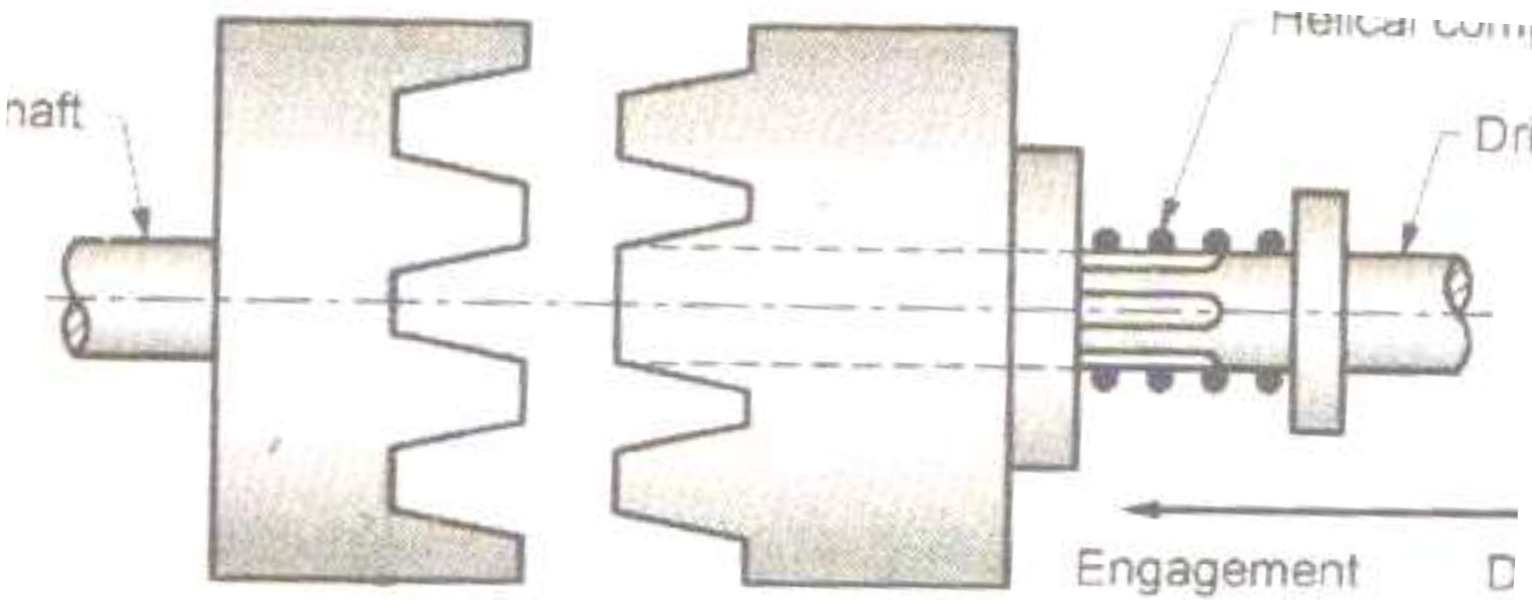
Trapezoidal or Truncated conical pivot

Sr. No.	Type of bearing	Uniform pressure theory p = Constant	Uniform wear theory $p \cdot r$ = Constant
1.	Flat pivot bearing	$p = \frac{W}{\pi R^2}$ $T = \frac{2}{3}\mu W R$	$T = \frac{1}{2}\mu W R$
2.	Flat collar pivot bearing (single collar)	$p = \frac{W}{\pi\left(R_1^2 - R_2^2\right)}$ $T = \frac{2}{3}\mu W\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = \frac{1}{2}\mu W (R_1 + R_2)$
3.	Multiple flat collar bearing	$p = \frac{W}{n \times \pi\left(R_1^2 - R_2^2\right)}$ $T = \frac{2}{3}\mu W\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = \frac{1}{2}\mu W (R_1 + R_2)$
4.	Conical pivot bearing	$p = \frac{W}{\pi R^2}$ $T = \frac{2}{3}\frac{\mu W R}{\sin\alpha}$	$T = \frac{1}{2}\frac{\mu W R}{\sin\alpha}$
5.	Trapezoidal or truncated conical bearing	$p = \frac{W}{\pi\left(R_1^2 - R_2^2\right)}$ $T = \frac{2}{3}\frac{\mu W}{\sin\alpha}\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = \frac{1}{2}\frac{\mu W (R_1 + R_2)}{\sin\alpha}$

Clutches

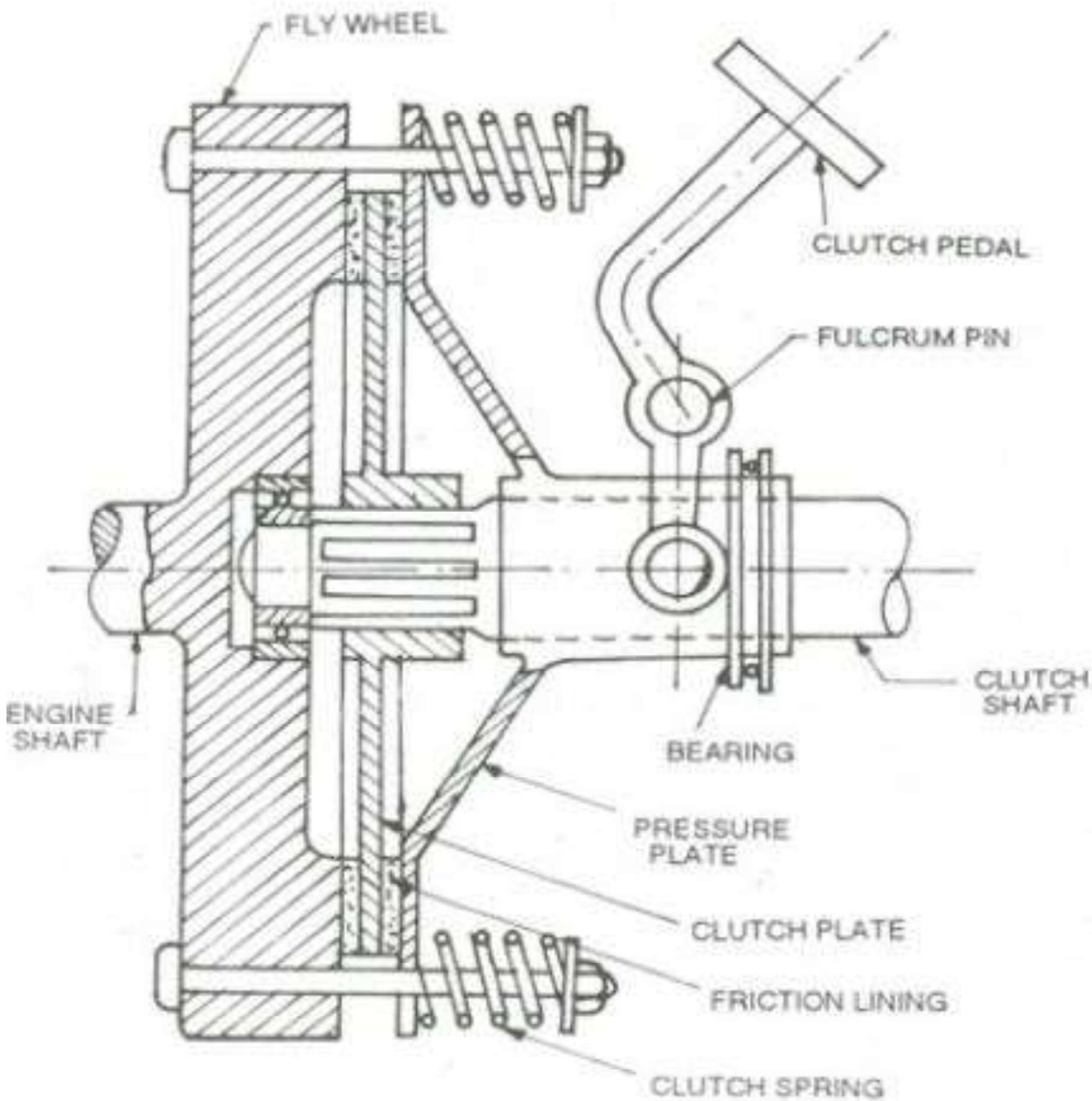
- Clutch is a mechanism to transmit rotary motion from one shaft to another coincident shaft as and when required without stopping the driver shaft.
- Types of clutches
  1) Positive clutches
     a) Jaw Clutch
  2) Friction clutches
     a) Disc or plate clutches
     b) Cone clutches
     c) Centrifugal clutches

Jaw clutch



These type of clutches are used in sprocket wheels, gears, pulleys etc.

Single plate clutch



Clutch Components

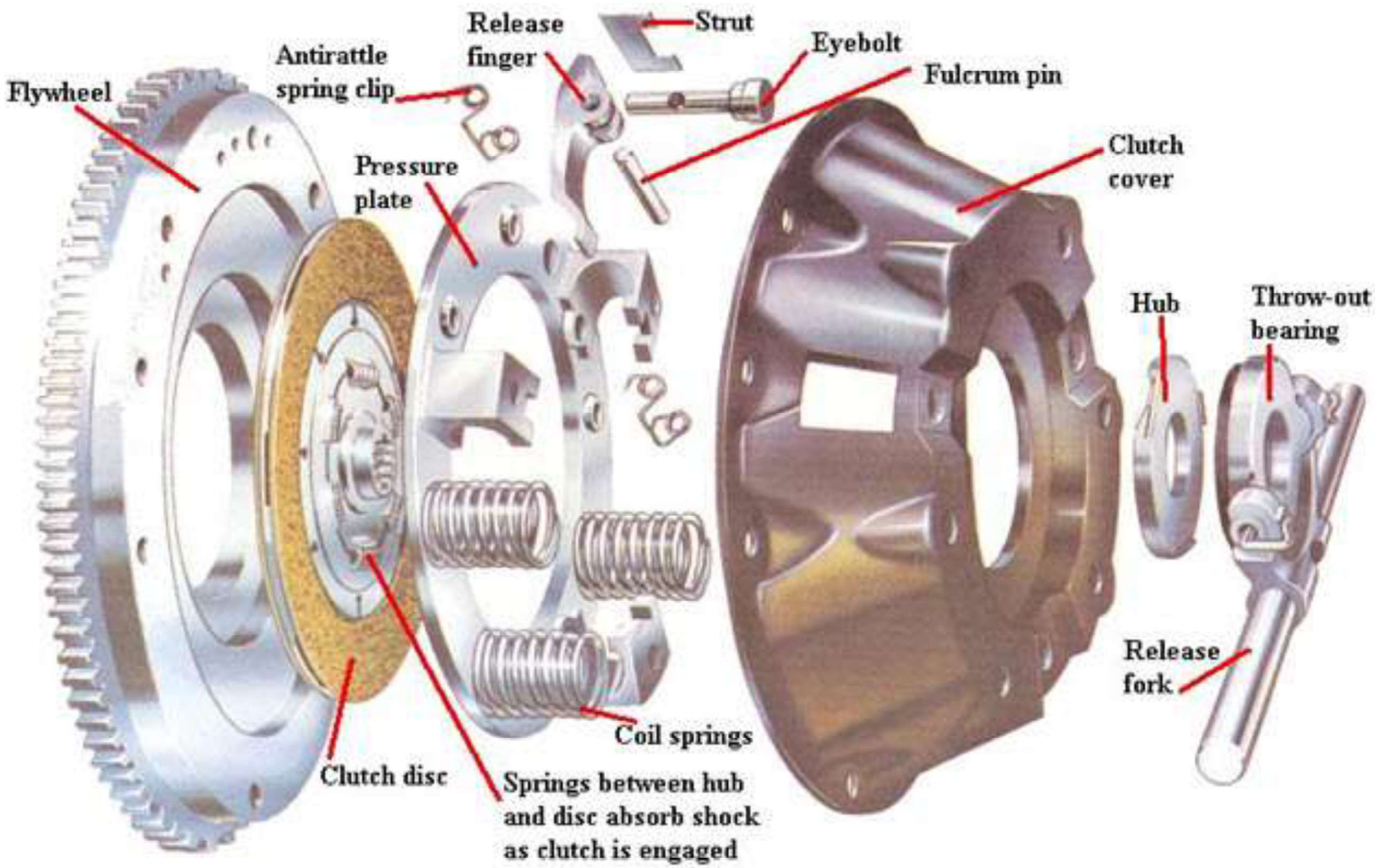
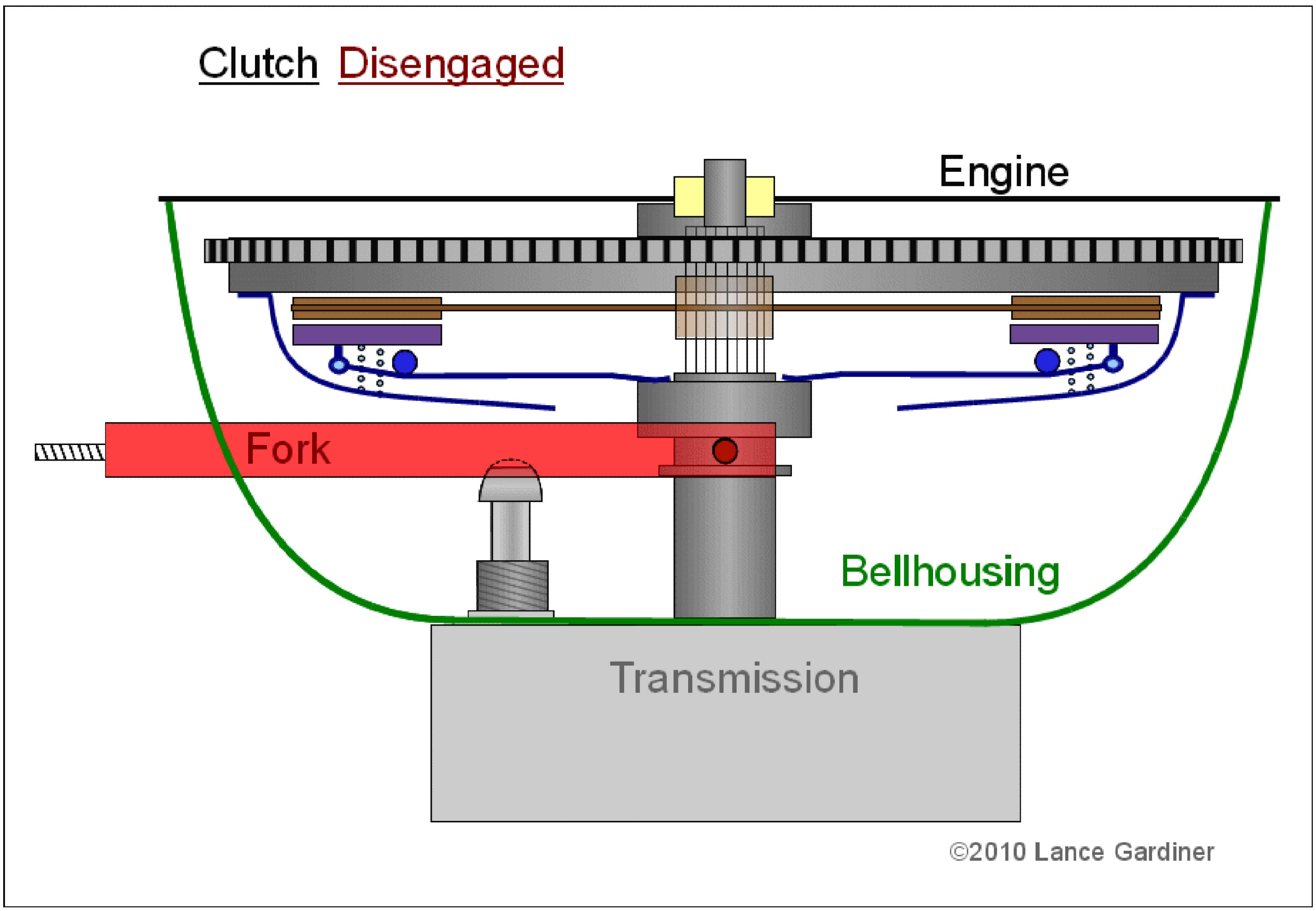
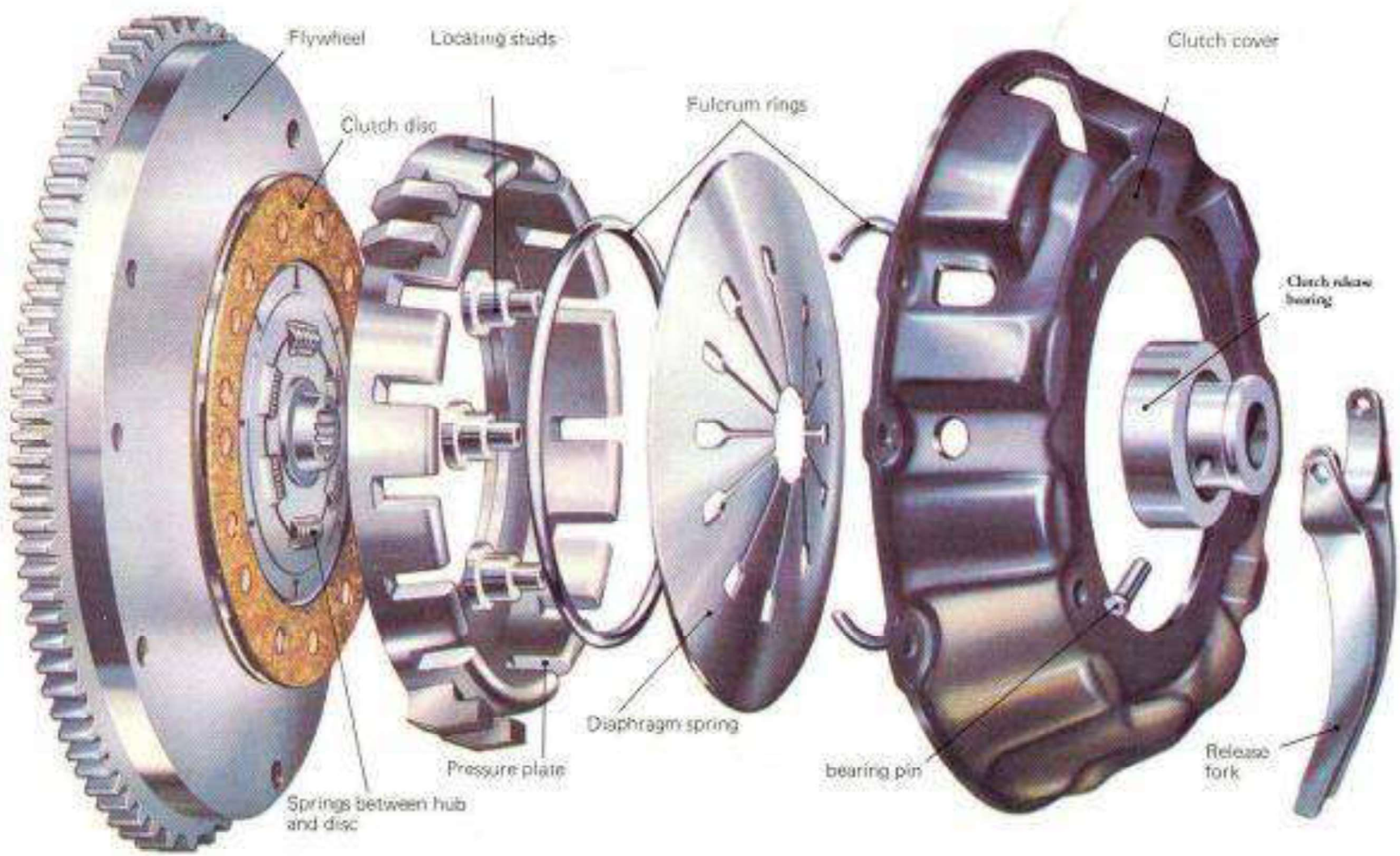


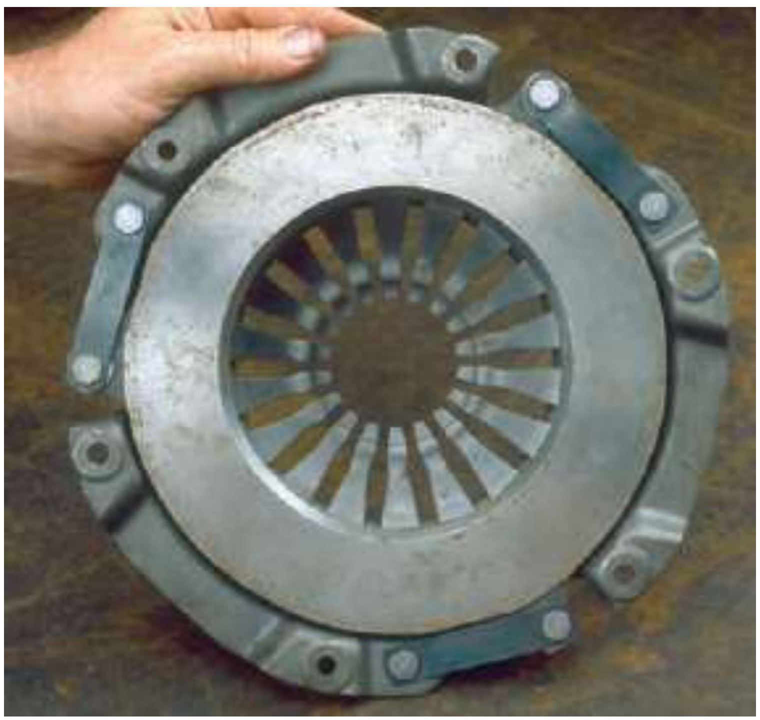
Fig. 10.1: Clutch

(Source: http://www.motorera.com/dictionary/pics/c/coil-spring_clutch.jpg)

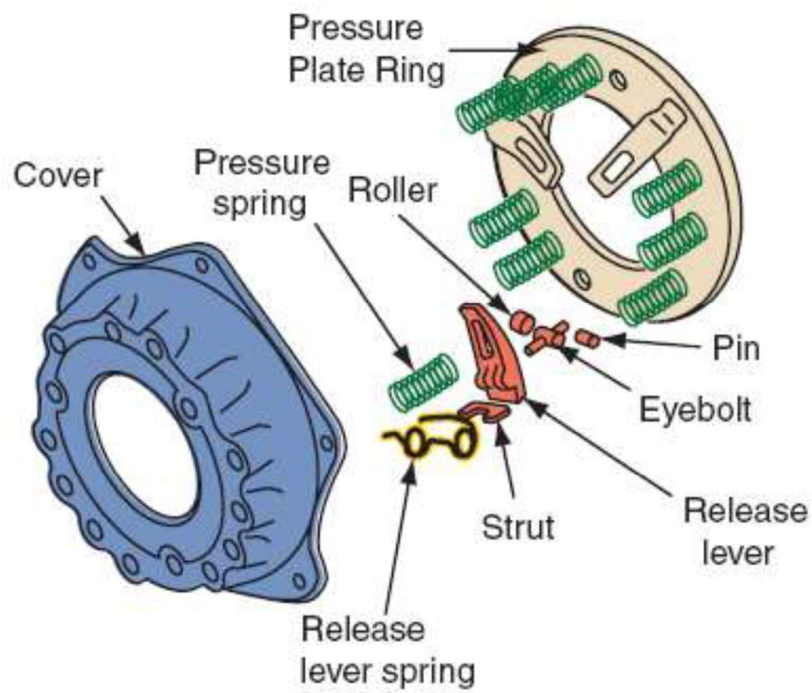

Clutch Disengaged
Engine
Fork
Bellhousing
Transmission
©2010 Lance Gardiner

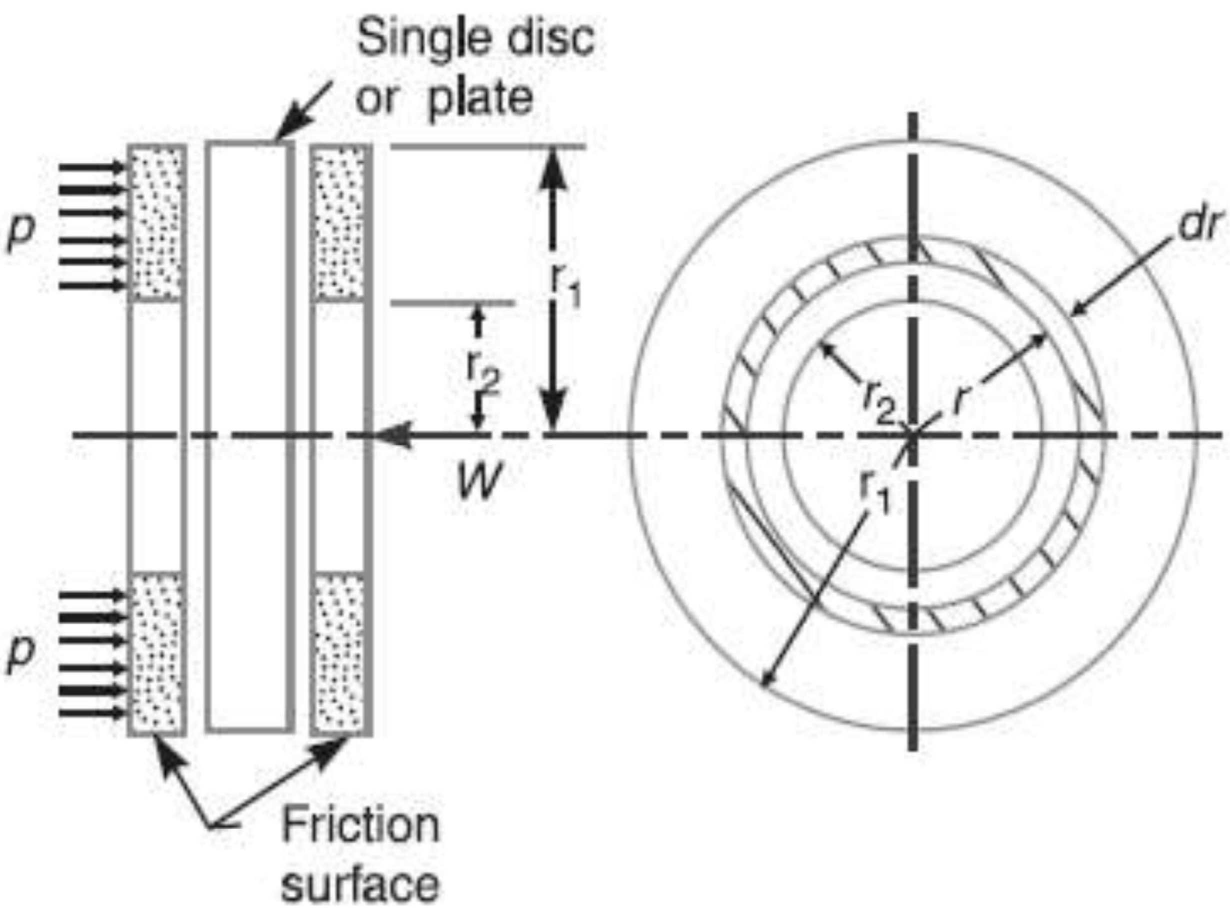

Flywheel
Locating studs
Clutch cover
Fulcrum rings
Clutch disc
Clutch release bearing
Diaphragm spring
Pressure plate
bearing pin
Release fork
Springs between hub and disc

Diaphragm Spring



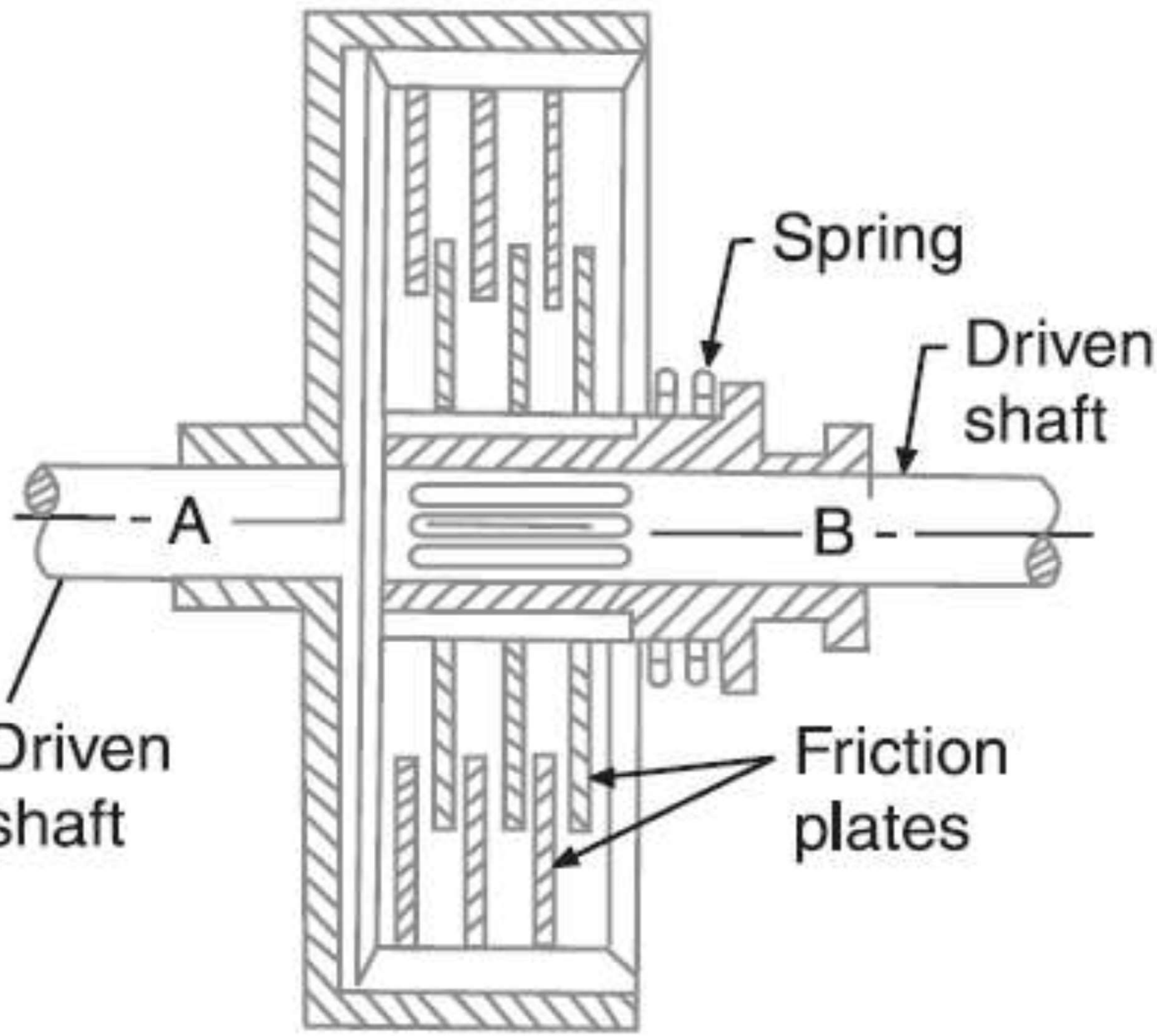
Coil Spring





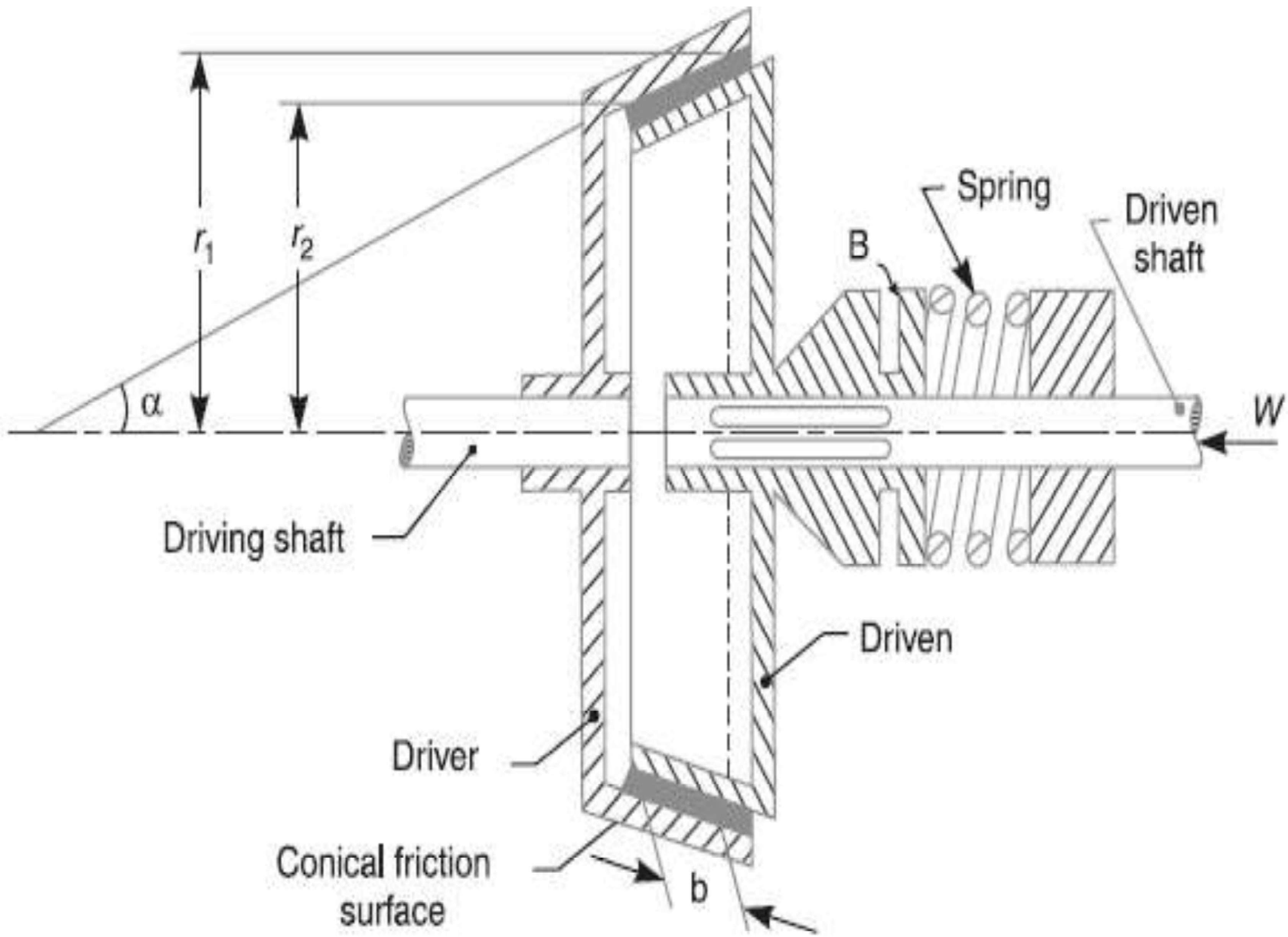
Single disc
or plate
p
r1
r2
W
dr
r2
r
r1
p
Friction
surface

Multi-plate Clutch

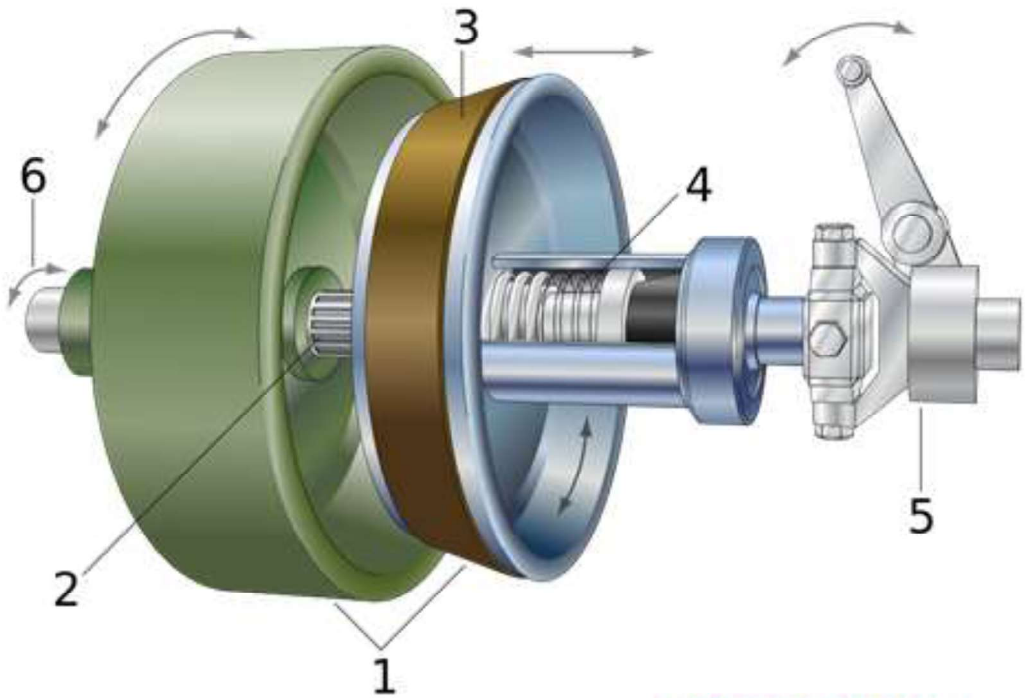



Clutch pedal
released
MECHANIC
MASTER

Cone clutch



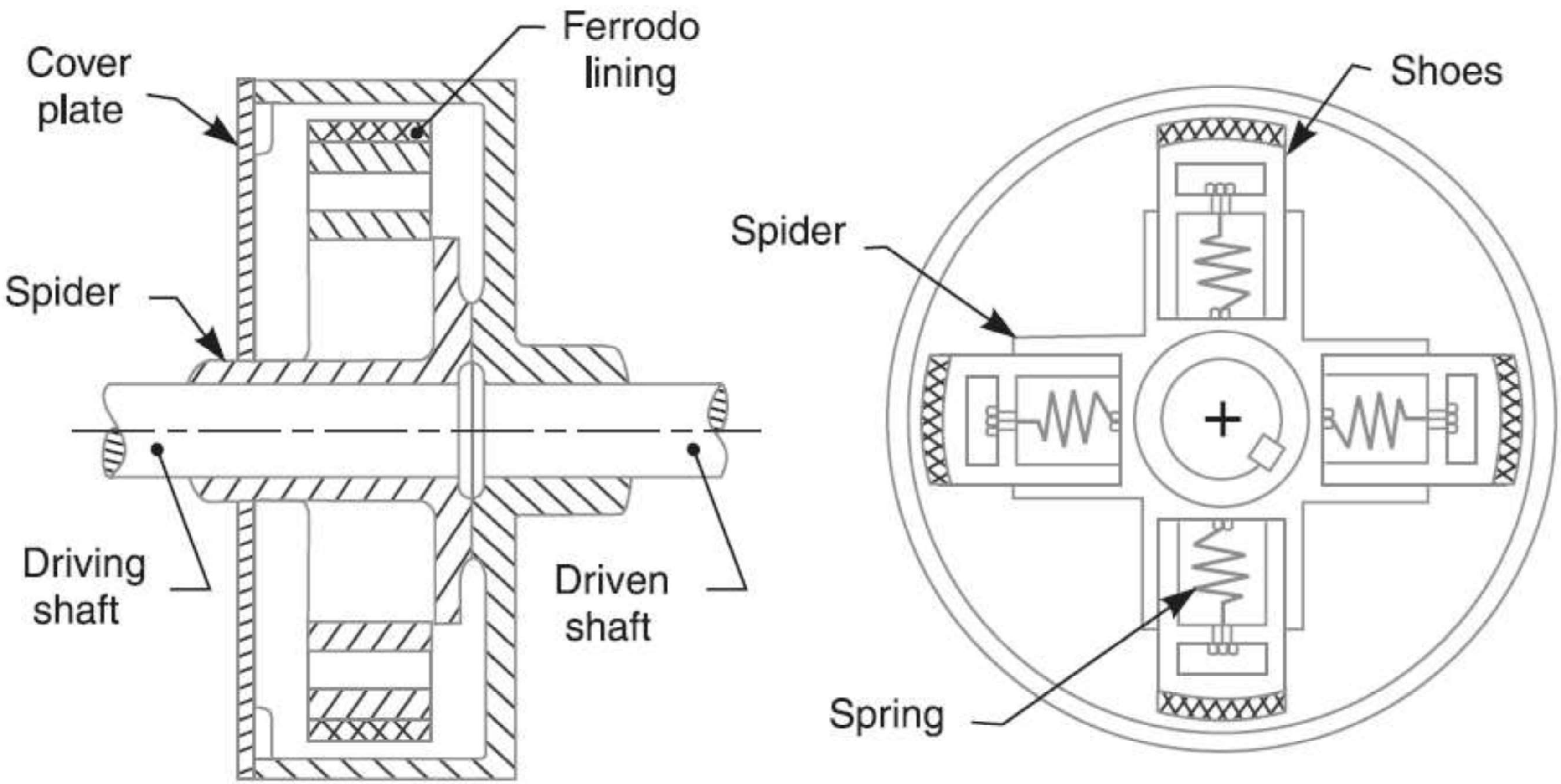
r_1
r_2
α
Spring
Driven
shaft
B
W
Driving shaft
Driven
Driver
Conical friction
surface
b



1: Female cone (green),
: Male cone (blue)
2: Shaft
3: Friction material
4: Spring
5: Clutch control
6: Direction of rotation

Cone Clutch

Centrifugal Clutch



[redacted]

Derivations

m = *Mass of each shoe,*

n = *Number of shoes,*

r = *Distance of centre of gravity of* the shoe from the centre of the spider,

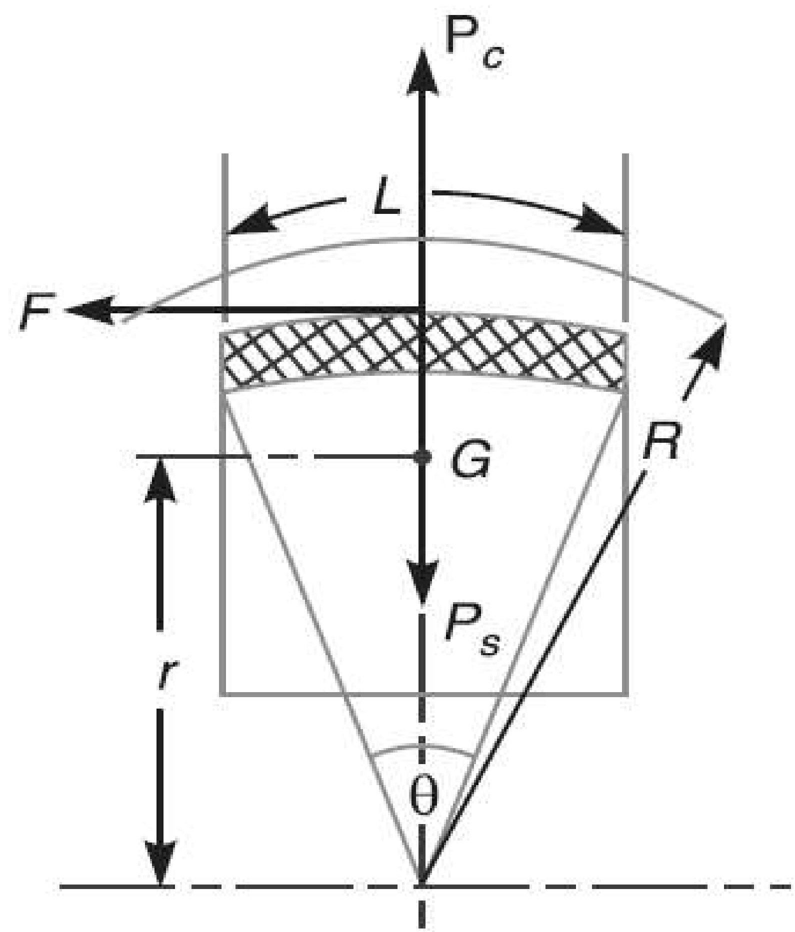
R = *Inside radius of the pulley rim,*

N = *Running speed of the pulley in* r.p.m.,

ω = Angular running speed of the pulley in rad/s = 2π*N/60 rad/s,*

ω1 = Angular speed at which the engagement begins to take place,

μ = Coefficient of friction between the shoe and rim



Torque

$$Pc = m.\omega^2.r$$

$$Ps = m\,(\omega_1)^2\,r$$

The net outward radial force= $Pc - Ps$

$$T = \mu\,(Pc - Ps)\,R \times n = n.F.R$$

Torque

l = *Contact length of the shoes,*

b = *Width of the shoes*

R = *Contact radius of the shoes. It is same as the inside radius of the rim*

of the pulley.

θ = Angle subtended by the shoes at the centre of the spider in radians.

p = *Intensity of pressure exerted on the shoe.*

$$\theta = l/R \text{ rad}$$

$$A = l.b$$

$$F = A \times p = l.b.p$$

$$l.b.p = Pc - Ps$$

Sr. No.	Types of clutch	Uniform pressure theory p = Constant	Uniform wear theory p · r = Constant
1.	Single plate clutch	$p = \frac{W}{\pi\left(R_1^2 - R_2^2\right)}$ $T = \frac{2}{3}\mu W\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = \frac{1}{2}\mu W\,(R_1 + R_2)$
2.	Multi-plate clutch	$T = n\times\frac{2}{3}\mu W\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = n\times\frac{1}{2}\mu W\,(R_1 + R_2)$
3.	Cone clutch	$p = \frac{W}{\pi\left(R_1^2 - R_2^2\right)}$ $T = \frac{2}{3}\frac{\mu W}{\sin\alpha}\left[\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}\right]$	$T = \frac{1}{2}\frac{\mu W}{\sin\alpha}\,(R_1 + R_2)$
4.	Centrifugal clutch	$T = n\times\mu\,(F_C - F_S)\times R_D$ $F_C - F_S = p\times l\times b$	