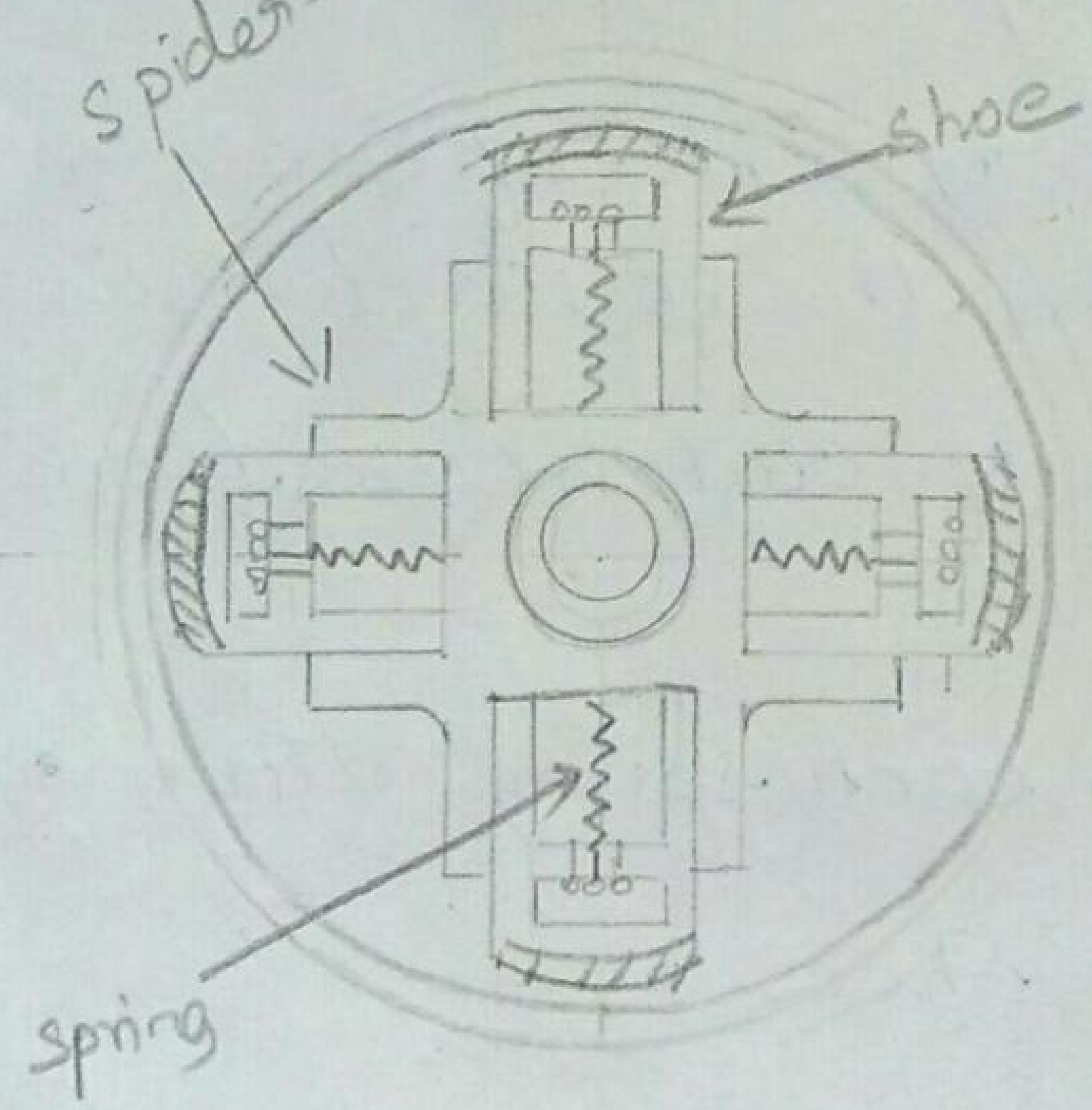
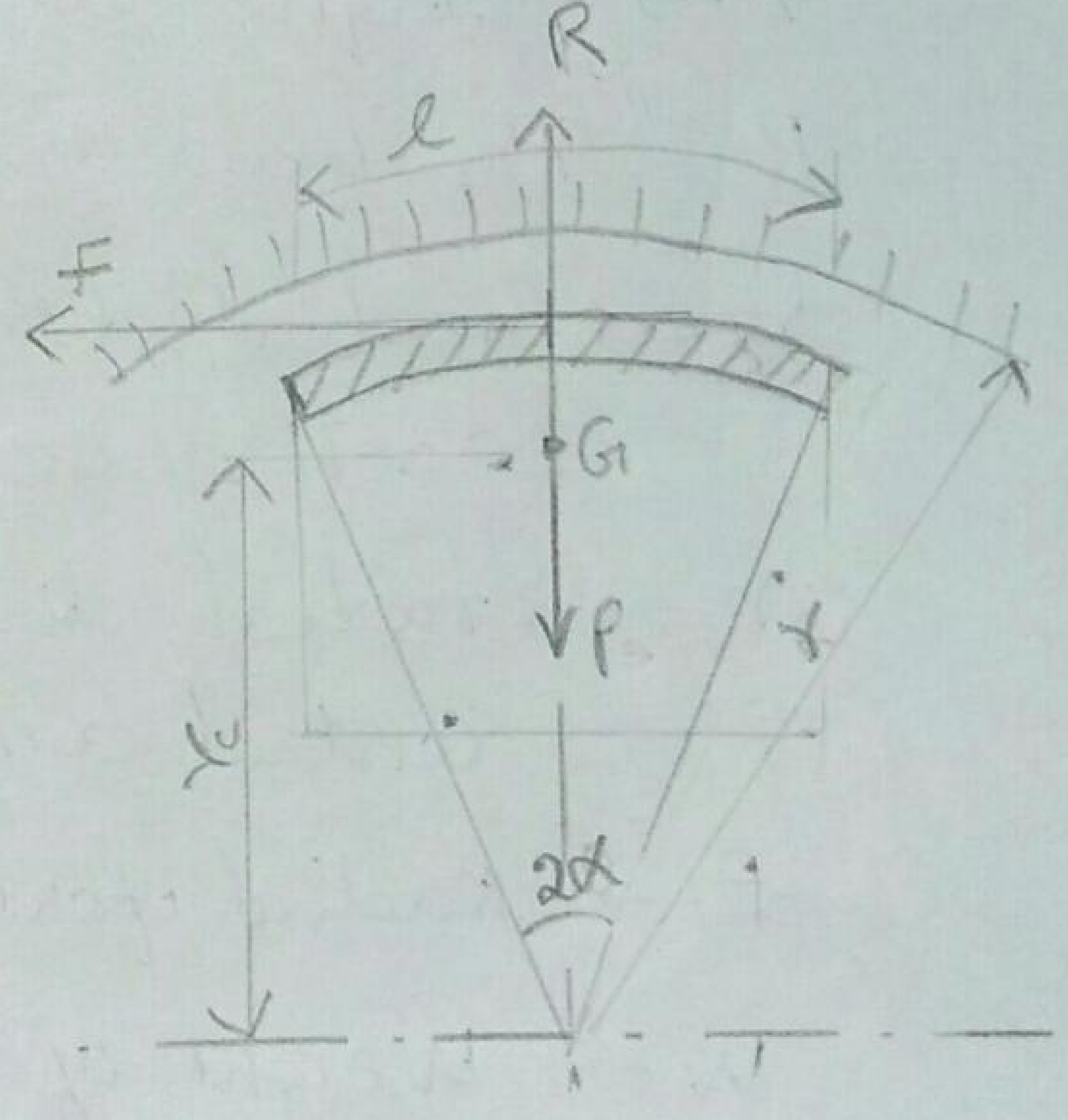
Design of Centrifugal Clutch

A cylindrical clutch casing contains four heavy blocks or shoes, which form the friction surface. The driving member consist of a spider carrying the four shoes, which are kept away from contact with the clutch case by means of the flat spring. Engagement of clutch takes place when the centrifugal force overcome the resistance of the springs. The power is transmitted by friction between the surface of shoes and the clutch case.





The Intensity of pressure ~~is assumed~~ between the contact surface is assumed to be uniform and also the angle subtended at the centre, O by the arc of contact is assumed to be small. Infact the assumption of uniform intensity of pressure is not strictly correct. The tangential friction force causes the tilting of the radial guides. Thus the resultant radial pressure on each shoe shifts from the centre line of the shoe.

Let

- $P \rightarrow$ Permissible Intensity of normal pressure on lining
- $2\alpha \rightarrow$ angle subtended at the center by the effective arc of contact
- $b \rightarrow$ Width of the clutch plate surface
- $T \rightarrow$ Torque transmitted due to friction
- $R \rightarrow$ Resultant radial pressure on each shoe.
- $r_c \rightarrow$ radial distance of center of gravity of each shoe from the central axis
- $r \rightarrow$ radial distance of clutch case from the central axis
- $P \rightarrow$ Radial force in each spring after engagement
- $W \rightarrow$ Weight of each shoe
- $m \rightarrow$ Mass of each shoe
- $N \rightarrow$ Speed
- $\omega \rightarrow$ Angular Velocity
- $x \rightarrow$ % of speed up to which the spring is able to overcome resistance.

Then, the length of arc in contact $= 2 r \alpha$

The length of chord of contact $= 2 r \sin \alpha$

Hence, $R = 2 p r b \sin \alpha \simeq 2 r p b \alpha$

as α is assumed small

$$T = 2 \mu p r^2 b \alpha = \mu R r$$

Now,

Centrifugal force $F = (W/g) \omega^2 r_c$

Since the spring is able to overcome the resistance up to x% of the speed, then

$$P = (W/g)(x \omega)^2 \times r_c$$

But,

$$R + P = (W/g) \omega^2 r_c$$

Therefore,

$$R = (W/g) \omega^2 r_c - (W/g) x^2 \omega^2 r_c$$

$$\boxed{R = (W/g) \omega^2 r_c (1 - x^2)}$$

Frictional force at each shoe surface $= \mu R$

$$= \mu (W/g) \omega^2 r_c (1 - x^2)$$

Frictional ~~fo~~ torque at each shoe $= \mu R r$

Frictional torque at 4 shoes $= 4 \mu R r$

Friction torque on fourshoe $= 4\mu (W/g)\omega^2 r_c r(1-x^2)$

This must be equal to the total torque transmitted $= \frac{60000 P_w}{2\pi N}$, where P_w is in kW

Hence

$$\frac{60000 P_W}{2\pi N} = 4\mu (W/g)\omega^2 r_c r(1-x^2)$$

Instead of x defined above, the analysis can also be done as follows:

Let, ω_e = angular speed at which the engagement begins to take place.

The centrifugal force acting on each shoe at running speed

$$F = (W/g)\omega^2 r_c$$

The inward force on each shoe exerted by the spring at the speed at which engagement begins to take place is given by

$$P = (W/g)\omega_e^2 r_c$$

$$R = F - P = (W/g)\omega^2 r_c - (W/g)\omega_e^2 r_c$$

$$R = (W/g) r_c (\omega^2 - \omega_e^2)$$

Frictional force acting tangential on each Shoe

$= \mu R = (W/g)\mu r_c(\omega^2 - \omega_e^2)$

Frictional torque at each shoe $= \mu R r$

$= (W/g)\mu r_c r(\omega^2 - \omega_e^2)$

There fore ~~torque~~ total frictional torque on "n" number of Shoes,

$$T = \mu R r n = (W/g)\mu r_c r n(\omega^2 - \omega_e^2)$$

Power transmitted, $P_w = T$

Then, $$\frac{60000 P_w}{2\pi N} = (W/g)\mu r_c r n(\omega^2 - \omega_e^2)$$

Normally radial clearance between the Shoe and the rim being very small as compared to r_c, it is neglected. If however, the radial clearance is given, then the operating radius of the mass center of the shoe from the axis of clutch

$r_o = r_c + c$, where $c \rightarrow$ radial clearance

In order to ensure normal life, the intensity of pressure, p may be taken as $9.81 \times 10^4 \ N/m^2$.