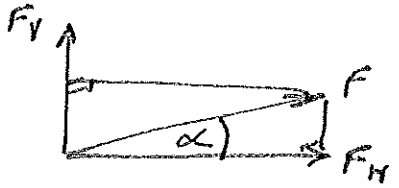
Resolution of forces



$$\sin\alpha = \frac{F_V}{F}$$

$$F_V = F\sin\alpha$$

$$\cos\alpha = \frac{F_H}{F}$$

$$F_H = F\cos\alpha$$

Coulomb's law

Strength of a force acting between two magnetic poles is given by

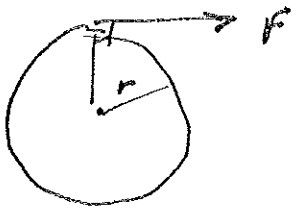
$$F = \frac{m_1 m_2}{kr^2}$$

where m_1, m_2 = strengths of the magnetic poles

r = distance between poles

k = constant.

TORQUE



$$T = Fr$$

Assumptions

1. Magnetic Poles are considered to be point forces.

2. The 'wheel' is restrained (mechanically) to prevent motion in any direction other than rotation on it about its axis — rotation in either direction is possible.

3. Region is such that: $\mu_1 = \mu_2$

k = constant

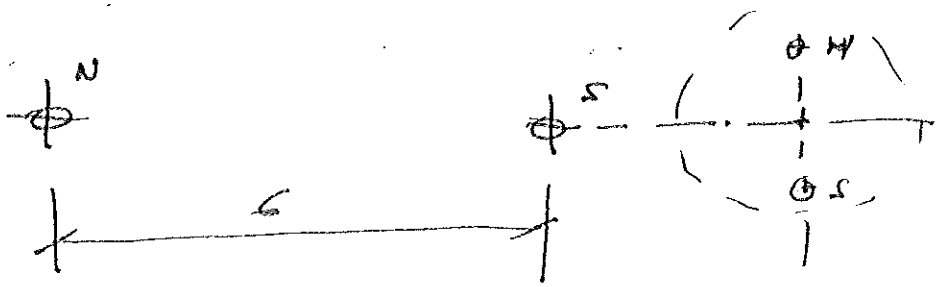
$$\therefore \frac{\mu_1 \mu_2}{k} = \beta$$

and from Coulomb's law

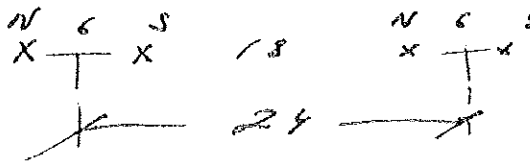
$$F = \frac{\beta}{r^2}$$

4. Geometric properties.

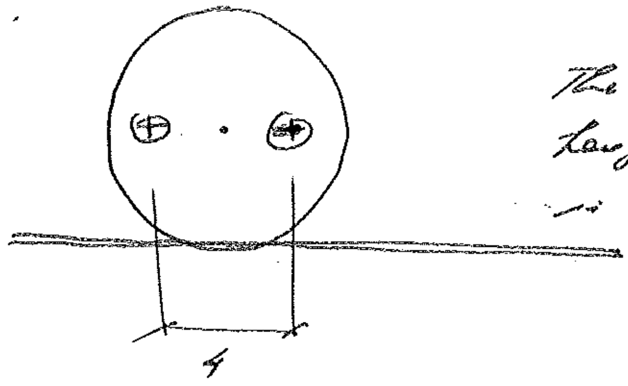
Stationary magnet mounted in pairs of opposite poles, 6 inch centre to centre in a horizontal plane at the same level as the axle of the rotating wheel. ie



Pairs pairs of stationary magnets mounted diametrically ie



The <u>Wheel</u> consists two poles spaced 4 units apart
ie



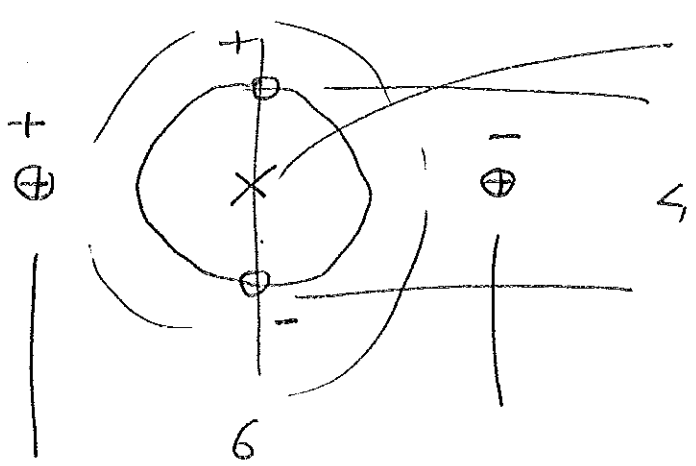
The wheel "drives" on a tangential track ie forward in the direction of rotation.

The wheel geometry is such that it will traverse 24 units in one revolution.

ie 1° of rotation $= \frac{24}{360} = 0.0\dot{6}$ units.

ANALYSING THE FORCES ON THE WHEEL DURING ONE COMPLETE REVOLUTION PAST A PAIR OF STATIONARY MAGNETS.

LET THE STARTING POSITION BE:



Axis of Rotation

Note the convention + = N [OR S]
− = S [OR N]

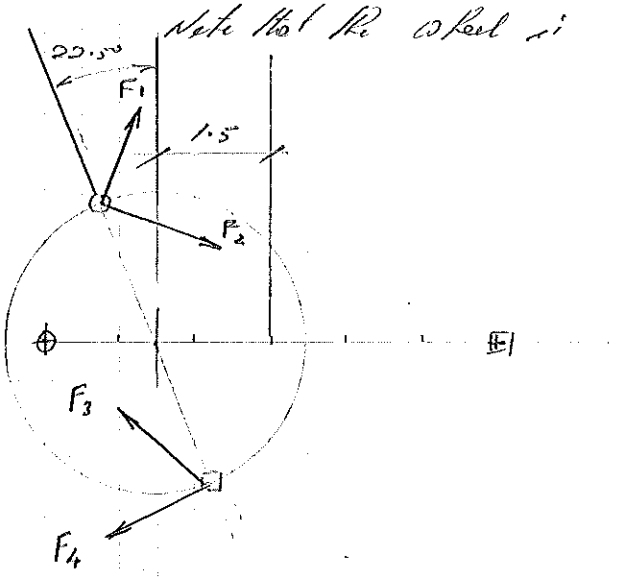
↺ + ANTICLOCKWISE TORQUE is considered +ve.

↻ CLOCKWISE TORQUE is considered −ve

22.5°/1.5

Position 22.5

ROTATION = 22.5°
TRAVERSE = 1.5 [$\frac{22.5 \times 24}{360^\circ}$ from Geometry of Wheel]

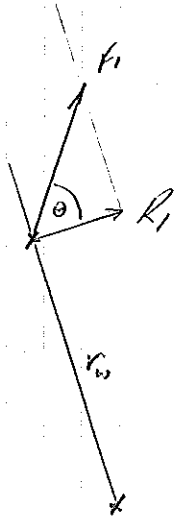


To determine the torque acting on the wheel, all forces need to be resolved to the tangential resultant forces

Let R_1 be the tangential force exerted by F_1

(ignoring R_2, R_3 & R_4)

Consider R_1



$R_1 = F_1 \cos\theta$

when $\theta = 46°$ (before started 22.5°)

$R_1 = 0.695 F_1$

$F_1 = \frac{\beta}{r_1}$

when $r_1 = 1.989$

$F_1 = 0.353\beta$

$\therefore R_1 = 0.176\beta$

$T_1 = -0.351\beta$ ↺

$F_1 = \beta / r_1^2$, $r_1 = 1.989$

$= 0.253\beta$

$R_1 = \cos\theta F_1$, $\theta = 46°$ (wijzer oklok 225)

$= 0.176\beta$

$T_1 = 2(0.176\beta)$

$= -0.352\beta$ ↷

$F_2 = \beta / r_2^2$, $r_2 = 5.578$

$= 0.032\beta$

$R_2 = \cos\theta F_2$, $\theta = 41°$

$= 0.024\beta$

$T_2 = 2(0.024)\beta$

$= -0.048\beta$ ↷

$F_3 = \beta / r_3^2$, $r_3 = 2.920$

$= 0.117\beta$

$R_3 = \cos\theta F_3$, $\theta = 62°$

$= 0.469 F_3 = 0.055\beta$

$T_3 = -0.109\beta$ ↷

$F_4 = \beta / r_4^2$, $r_4 = 4.170$

$= 0.058\beta$

$R_4 = \cos\theta F_4$, $\theta = 4°$

$= 0.058\beta$ ~~0.057β~~

$T_4 = -0.115\beta$ ↷

$\Sigma T = T_1 + T_2 + T_3 + T_4$

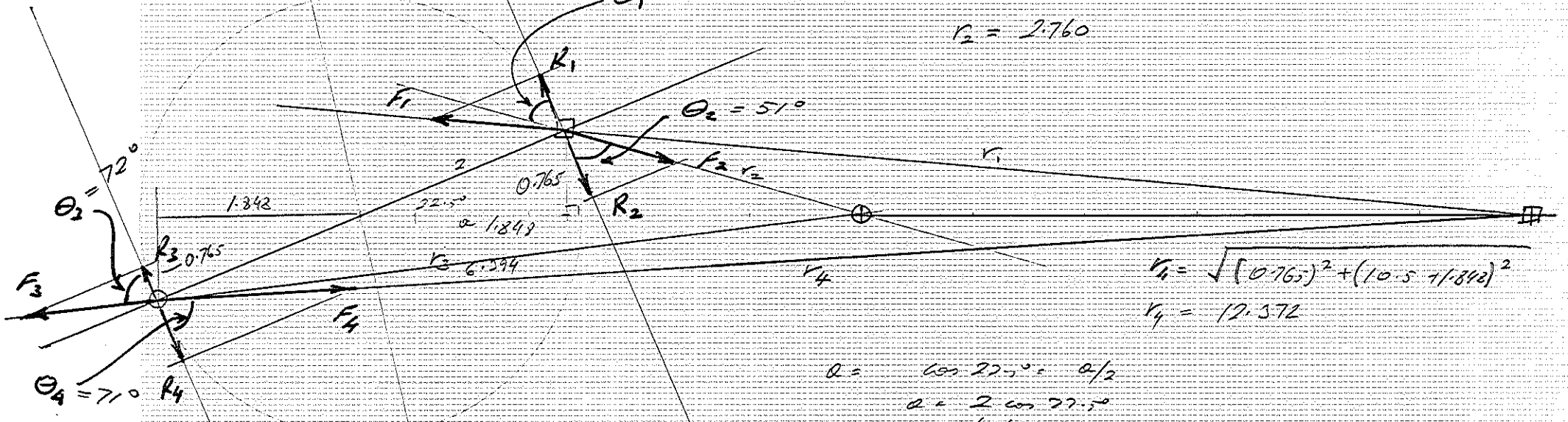
$= -(0.352 + 0.048 + 0.109 + 0.115)\beta$

$= -0.624\beta$ ↷

SEARCH 112.5°

ROTATION = 112.5°

RANGE = 7.5°



$r_2 = \sqrt{(0.765)^2 + (4.5 + 1.848)^2}$

$r_2 = 6.394$

$r_2 = \sqrt{(0.765)^2 + (4.5 - 1.848)^2}$

$r_2 = 2.760$

$r_4 = \sqrt{(0.765)^2 + (10.5 + 1.842)^2}$

$r_4 = 12.372$

$a = \cos 22.5° = a/2$

$a = 2 \cos 22.5°$

$= 1.848$

$\sin 22.5° = \frac{s}{2}$

$s = 2 \sin 22.5° = 0.765$

$r_1 = \sqrt{(0.765)^2 + (10.5 - 1.848)^2}$

$= 8.686$

112.5°/7.5

$F_1 = \beta / r_1^2$, $r_1 = 8.686$
$= 0.013\beta$

$R_1 = F_1 \cos\theta_1$, $\theta_1 = 62°$
$= 0.006\beta$
$T_1 = +0.012\beta$ ↖

$F_2 = \beta / r_2^2$, $r_2 = 2.760$
$= 0.131\beta$
$R_2 = F_2 \cos\theta_2$, $\theta_2 = 51°$
$= 0.083\beta$
$T_2 = -0.165\beta$ ↗

$F_3 = \beta / r_3^2$, $r_3 = 6.394$
$= 0.024\beta$
$R_3 = F_3 \cos\theta$, $\theta_3 = 72°$
$= 0.008\beta$
$T_3 = -0.015\beta$ ↗

$F_4 = \beta / r_4^2$, $r_4 = 12.372$
$= 0.007\beta$
$R_4 = F_4 \cos\theta_4$, $\theta_4 = 71°$
$= 0.002\beta$
$T_4 = +0.004\beta$ ↖

$\sum T = 0.016 - 0.180$
$= -0.164$ ↗