Engine dynamics-Ex1
Forces acting on bearings without balancing

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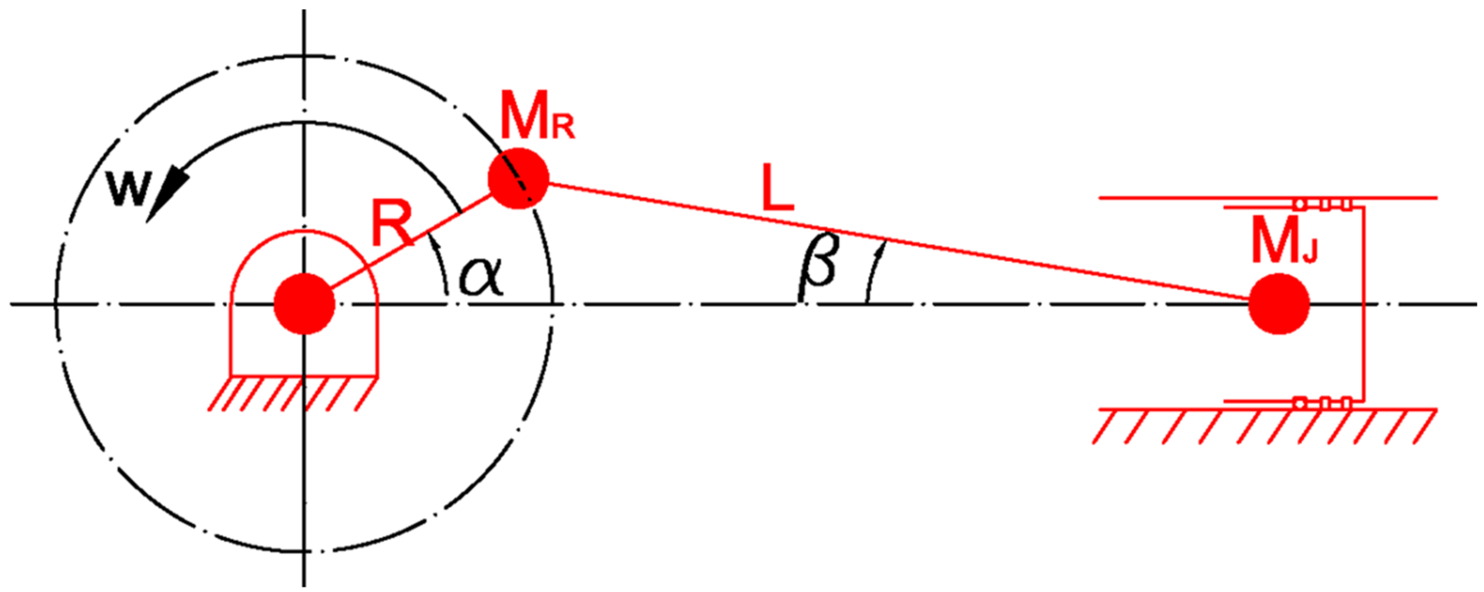


- n=5000 d/d
- R=64/1000;
- m_{piston}=679.15/1000; %kg
- $m_{ringoil}$=25.92/1000; %kg
- m_{cp}=131.47/1000; %kg
- ρ=18.61/1000; %m
- m_b=707.03/1000; %kg
- m_{crp}=0.2278*mb

D=100 mm

$\lambda =$64/198,55=0,322

$m_{ringcomp}$=14.39/1000; %kg

m_{wp}=147.67/1000; %kg

m_w=1522.13/1000; %kg

Pg@30°DCA=1 Bar

L=198.55/1000; %m

$\alpha =$30 DCA

Beta

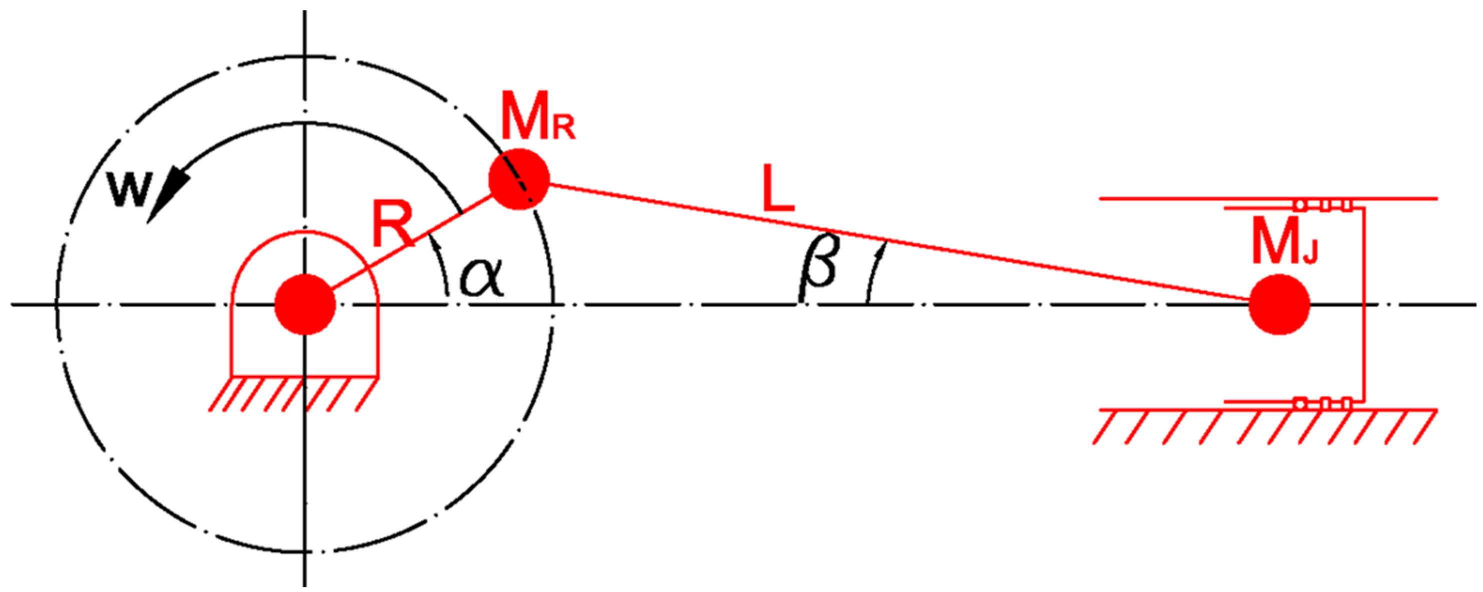
$Lsin(\beta) = Rsin(\alpha)$

$sin(\beta)=\lambda sin(\alpha)$

$\beta = \text{asin}(\lambda \sin \alpha)$

$\beta = \text{asin}(0{,}322 * \sin 30)$

$\beta = 9.27°$



m_j

$$m_p = m_{piston} + m_{wp} + \sum m_{ring}$$

$$m_p = 0.67915 + 0.14767 + (25{,}92 + 2 * 14{,}39) / 1000$$

$$m_p = 0.88152 kg$$

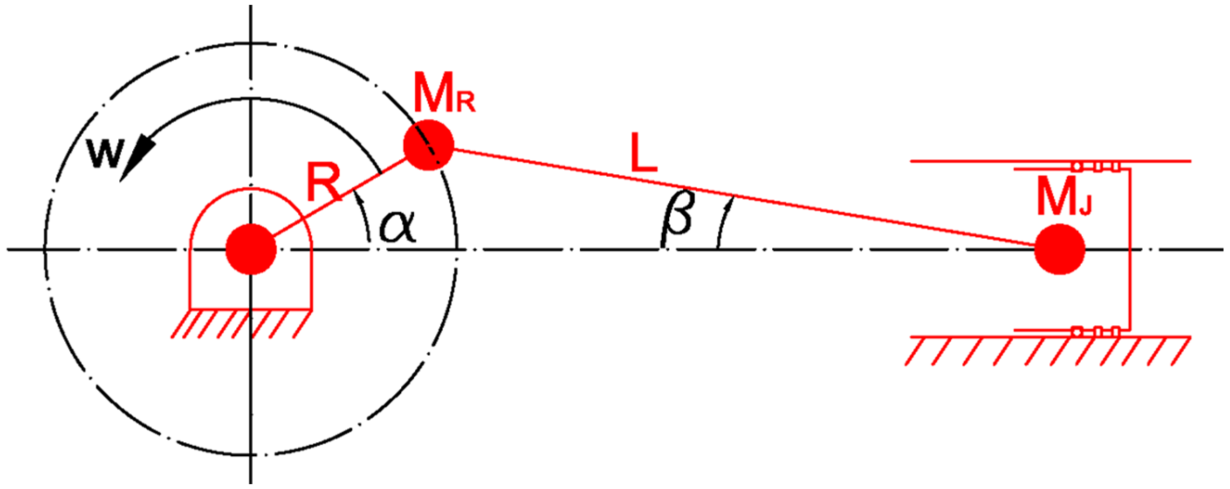
$$m_j = m_{piston} + m_{wp} + \sum m_{ring} + m_{crp}$$

$$m_{crp} = 0{,}2278 * mb$$

$$m_{crp} = 0{,}2278 * 0{,}70703 = 0{,}161 kg$$

$$m_j = m_{piston} + m_{wp} + \sum m_{ring} + m_{crp}$$

$$m_j = 0{,}88152 + 0{,}161 = 1{,}0426 kg$$



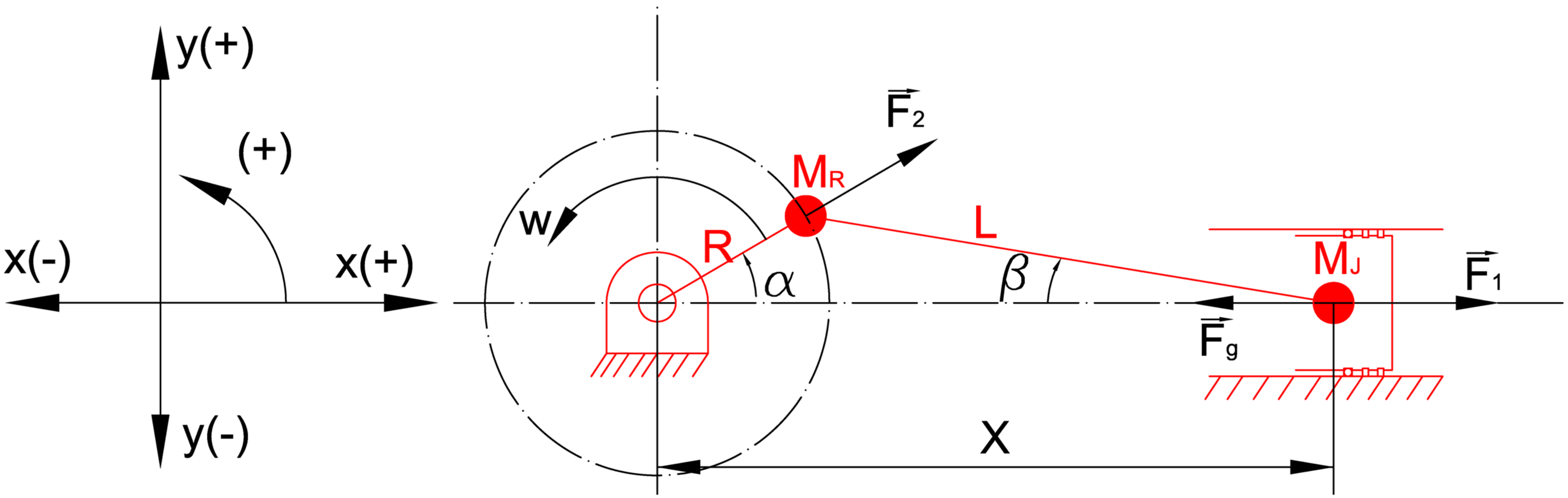
m_R

$$m_R = m_{cp} + 2m_w \frac{\rho}{R} + m_{crc}$$

$$m_R = 0,1315 + 2*1,522*\frac{18,61/1000}{64/1000} + 0,545$$

$$m_R = 1,562kg$$

Coordinate system and forces



F_g

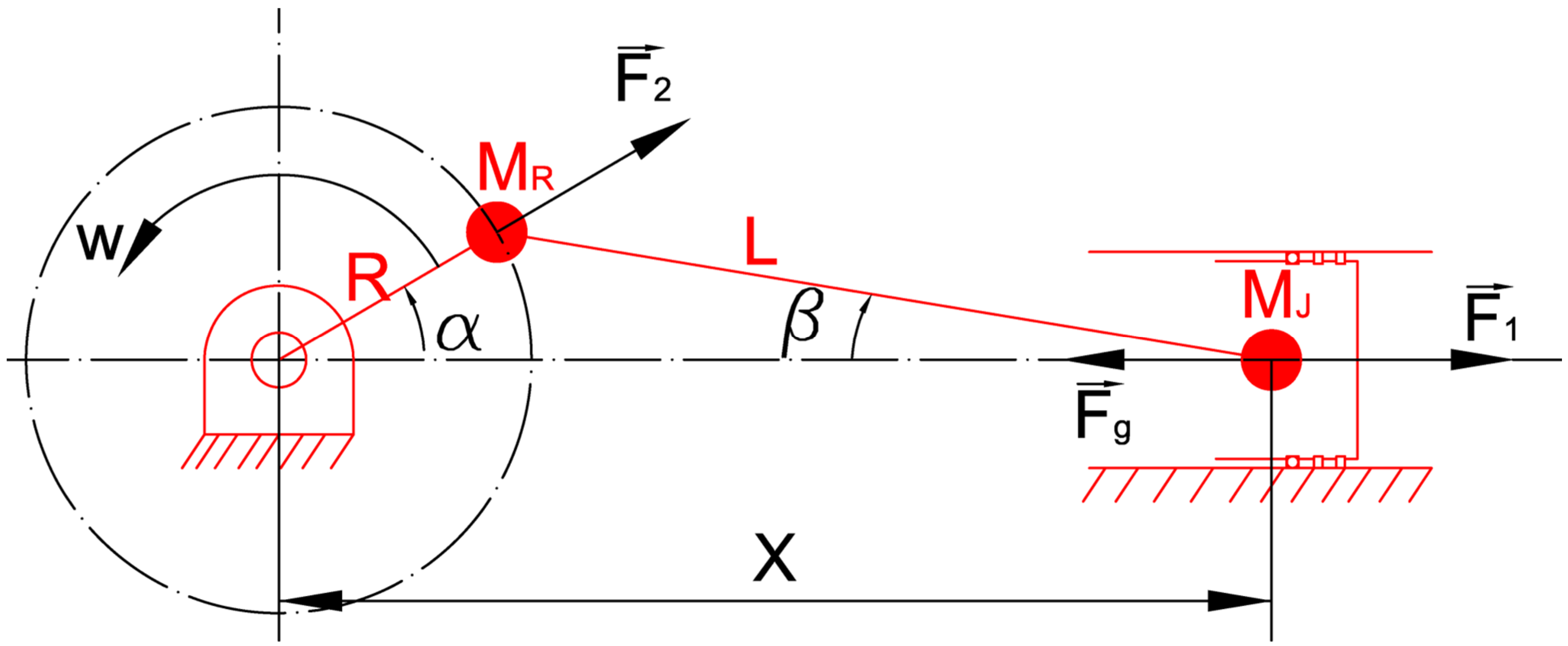
$$P = \frac{F}{A}$$

$$F_g = P(\alpha).A$$

$$F_g = P(\alpha).\left(\frac{\pi D^2}{4}\right)$$

$$F_g = 1.10^5.\left(\frac{\pi\left(100/1000\right)^2}{4}\right)$$

$$\overrightarrow{F_g} = 785\measuredangle 180°\ N$$



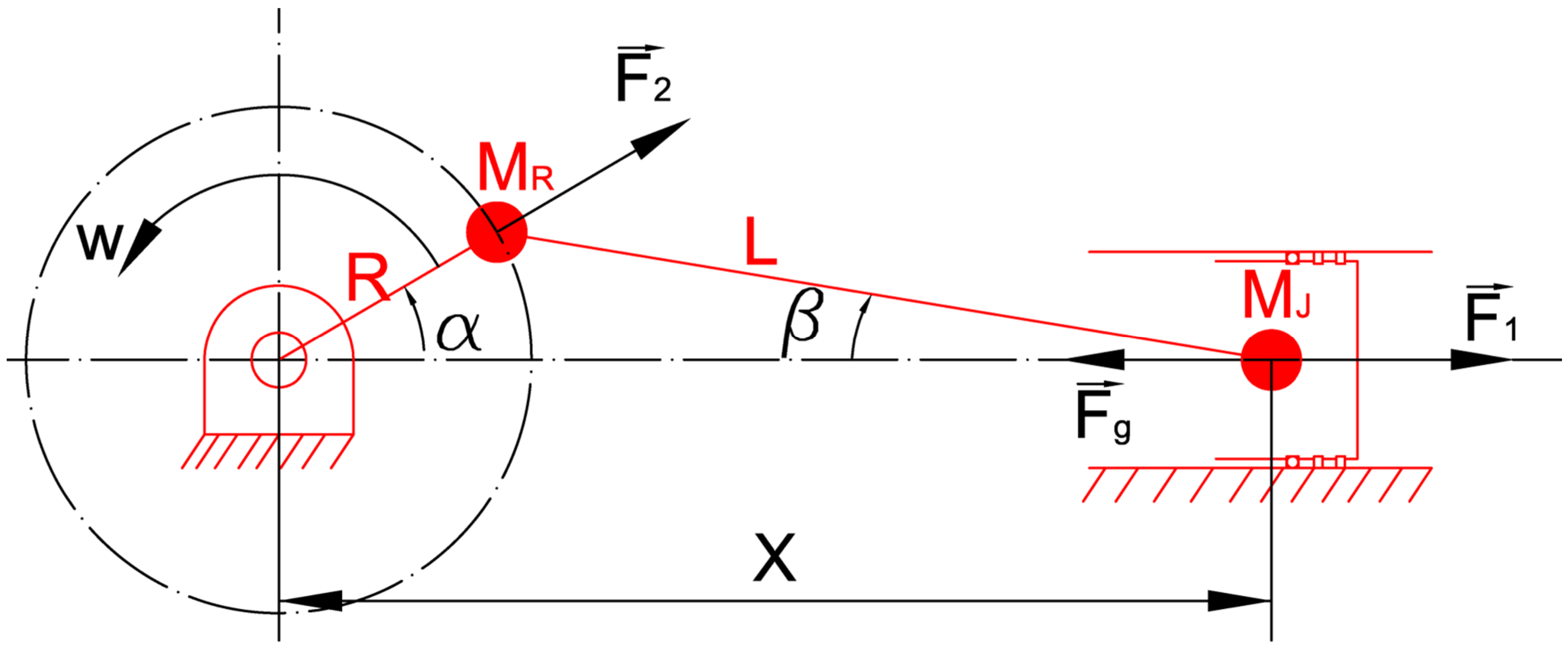
w, λ

$$w = 5000 * 2\pi / 60$$

$$w = 523.59\, rad / s$$

$$\lambda = \frac{R}{L}$$

$$\lambda = \frac{64}{198.55} = 0.322$$

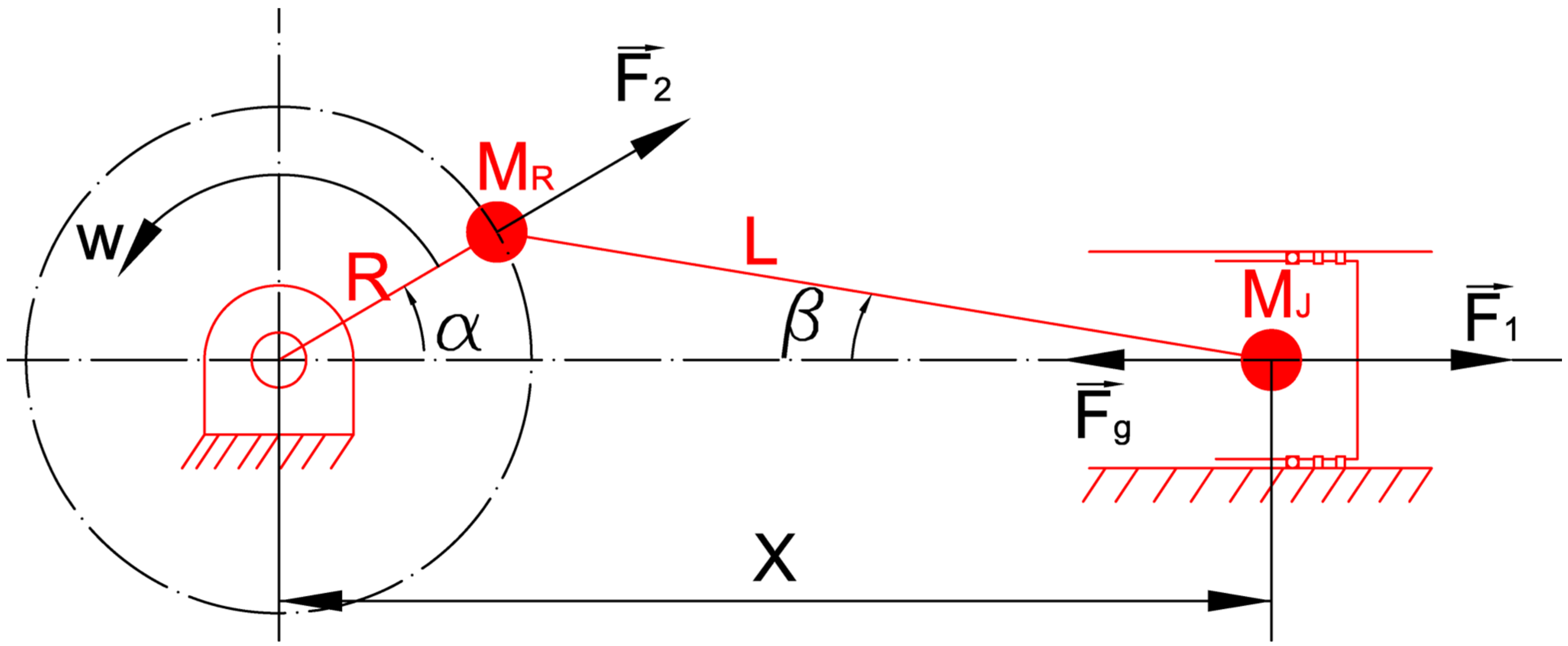


F_1

$$\vec{F_1} = -m_j - w^2 R\left[\cos\alpha + \lambda\cos 2\alpha\right]\measuredangle 0°$$

$$\vec{F_1} = 1.042.(523,59)^2.\frac{64}{1000}.\left[\cos 30 + \lambda\cos 60\right]\measuredangle 0°$$

$$\vec{F_1} = 18766.36\measuredangle 0°\, N$$

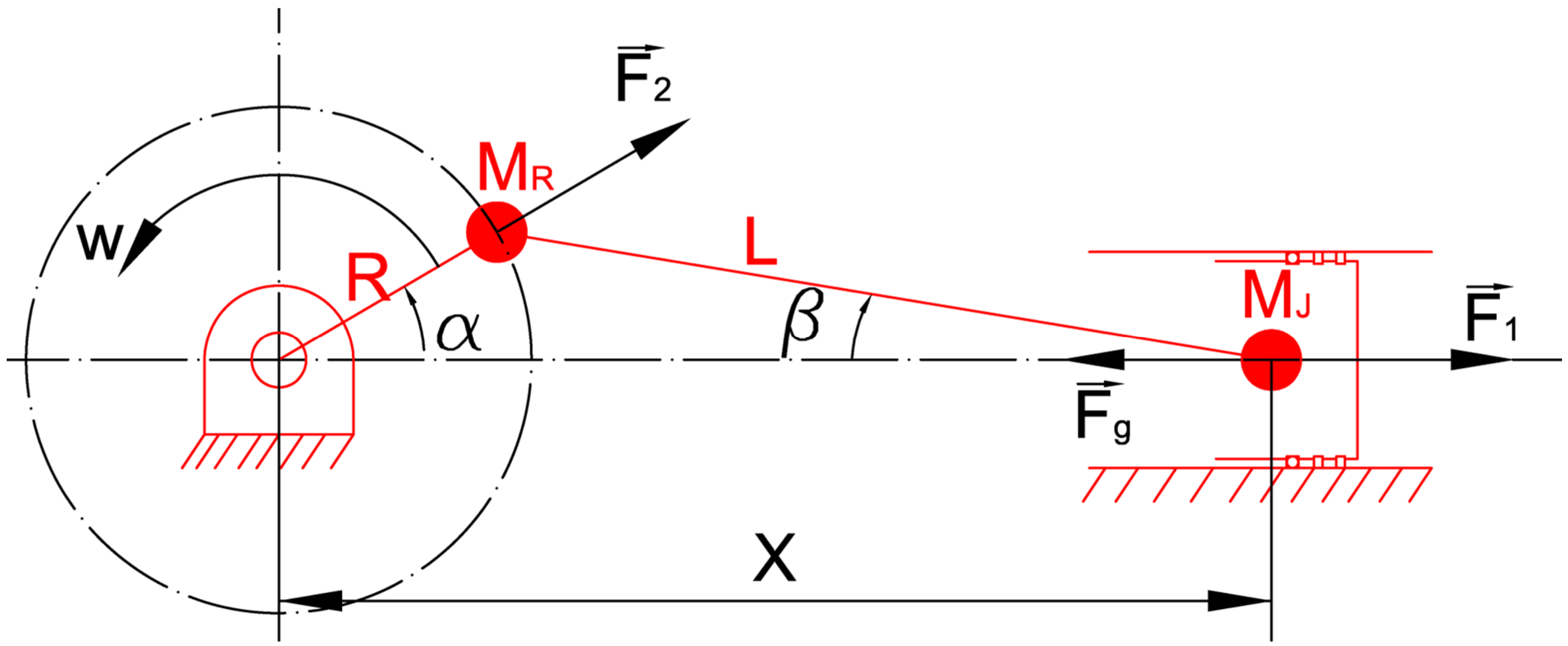


F_2

$$\overrightarrow{F_2} = m_R.R.w^2 \measuredangle \alpha$$

$$\overrightarrow{F_2} = (1.562).\frac{64}{1000}.(523.59)^2 \measuredangle \alpha$$

$$\overrightarrow{F_2} = 27405.87 \measuredangle \alpha \ N$$



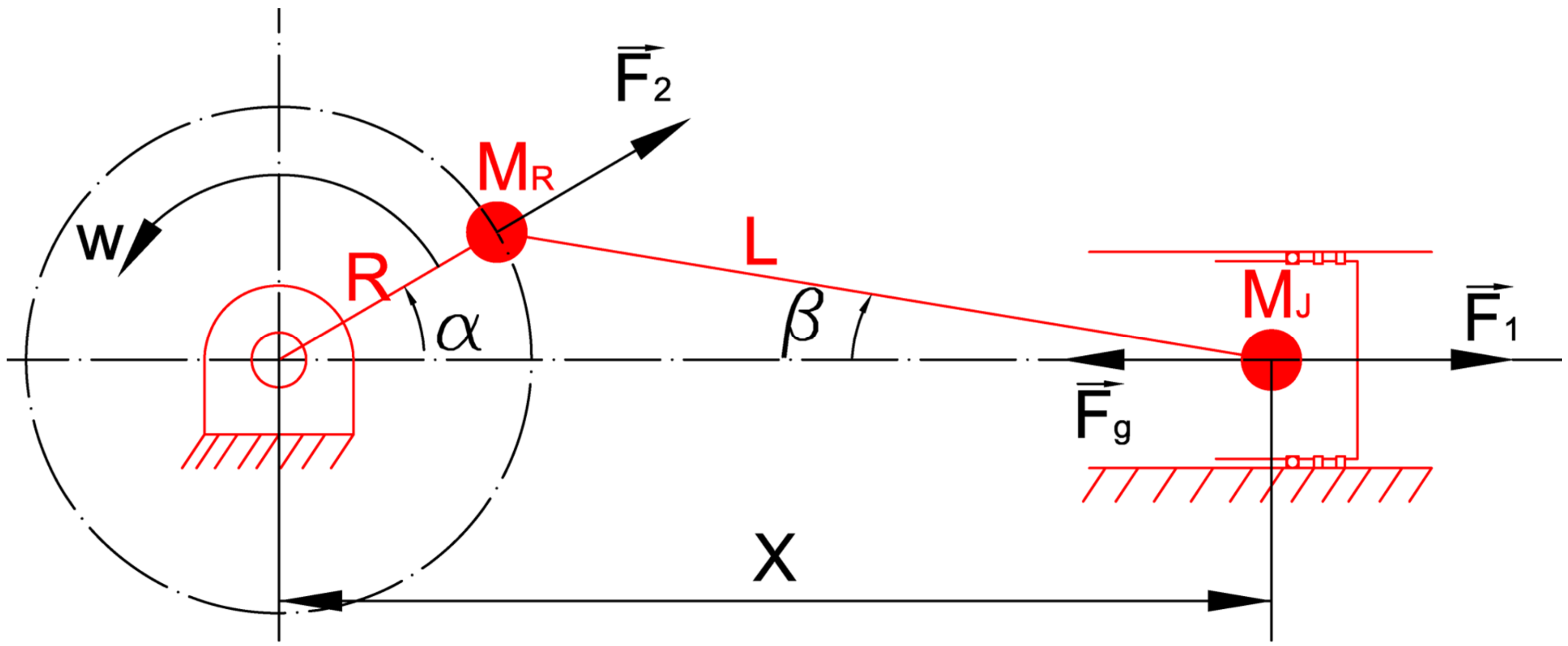
Total force acting on main bearings w/o balance

$$\overrightarrow{F_g} = 785\measuredangle 180°\ N$$

$$\overrightarrow{F_1} = 18766.36\measuredangle 0°\ N$$

$$\overrightarrow{F_2} = 27405.87\measuredangle \alpha\ N$$

$$\sum \vec{F} = \vec{F}_g + \vec{F}_1 + \vec{F}_2$$



Total force acting on main bearings w/o balance

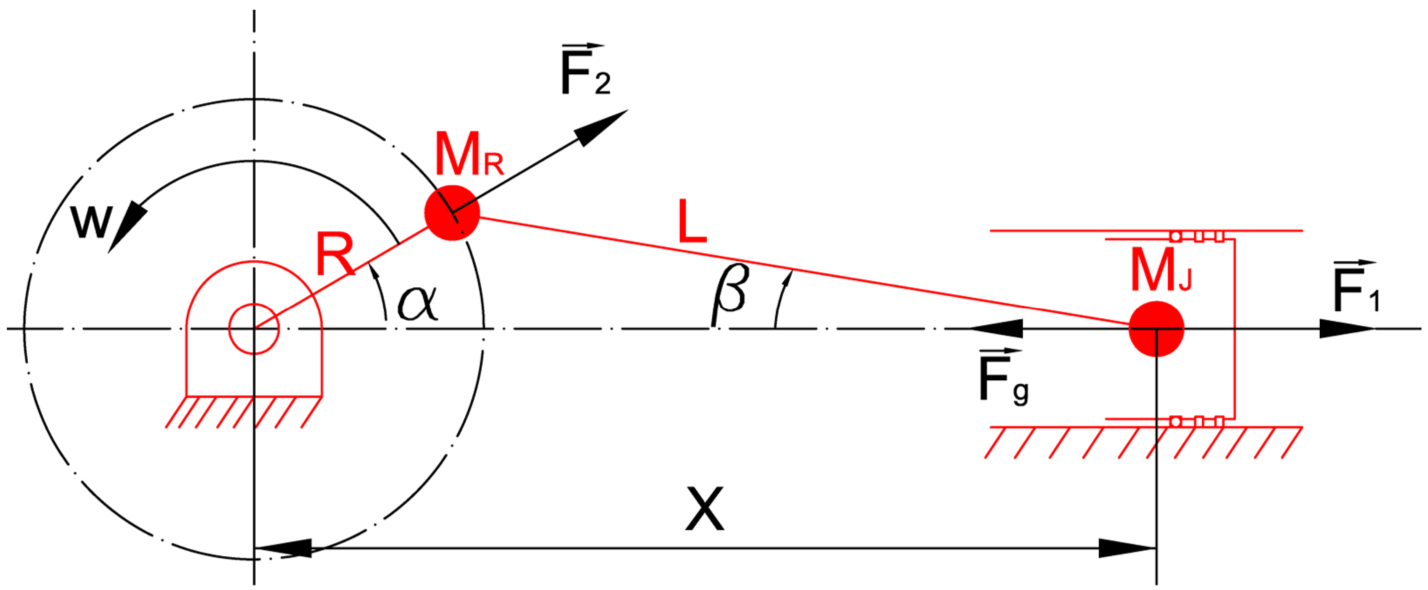
$$\sum \vec{F} = 785\measuredangle 180° + 18766.36\measuredangle 0° + 27405.87\measuredangle \alpha$$

$$\sum \vec{F} = 43907.33\measuredangle 18.18°\ N$$

Total resultant force is calculated, but each bearing carries the load equally hence the force acting on each bearing is obtained then,

$$\vec{F} = 43907.33\measuredangle 18.18° / 2$$

$$\vec{F} = 21953.66\measuredangle 18.18°\ N$$



F3

$$\overrightarrow{F_3} = \left|F_1 / \cos\beta\right| \measuredangle (360-\beta)^\circ \left\{\ddot{X} < 0 \; \& \; \beta > 0\right\}$$

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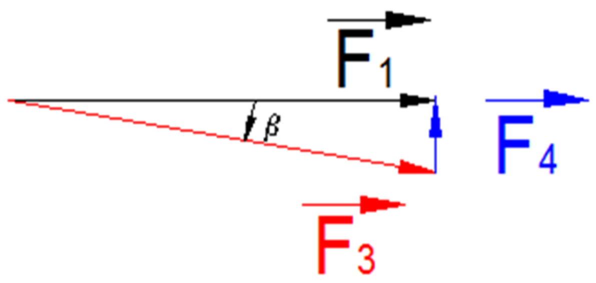
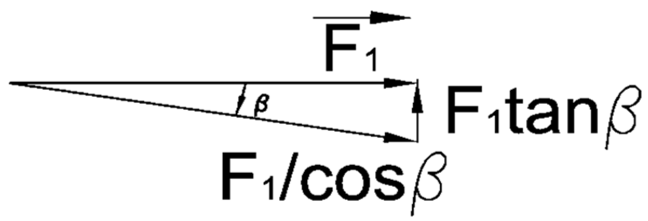
$$\overrightarrow{F_3} = \left|F_1 / \cos\beta\right| \measuredangle (180-\beta)^\circ \left\{\ddot{X} > 0 \; \& \; \beta > 0\right\}$$

$$\overrightarrow{F_3} = \left|F_1 / \cos\beta\right| \measuredangle (180-\beta)^\circ \left\{\ddot{X} > 0 \; \& \; \beta < 0\right\}$$



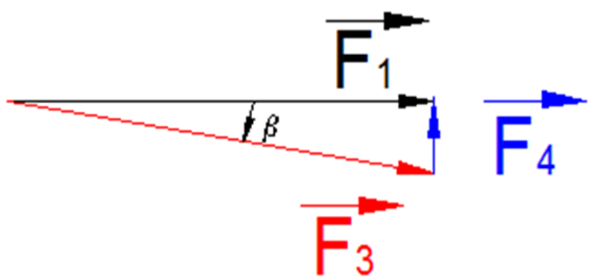


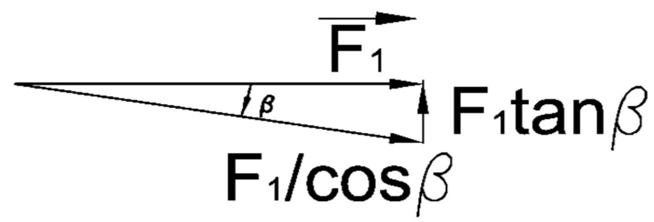
F3

$$\overrightarrow{F_3} = \left|F_1 / \cos\beta\right| \measuredangle (360 - \beta)^\circ \left\{\ddot{X} < 0 \ \& \ \beta > 0\right\}$$

$$\overrightarrow{F_3} = \left|18766.36 / \cos 9.27\right| \measuredangle (360 - \beta)^\circ$$

$$\overrightarrow{F_3} = 19015.46 \measuredangle (350.73)^\circ \text{ N}$$





F5

$$\overrightarrow{F_5} = \left| F_g / \cos\beta \right| \measuredangle (180 - \beta)^\circ$$

$$\overrightarrow{F_5} = \left| 785 / \cos 9.27 \right| \measuredangle (180 - 9.27)^\circ$$

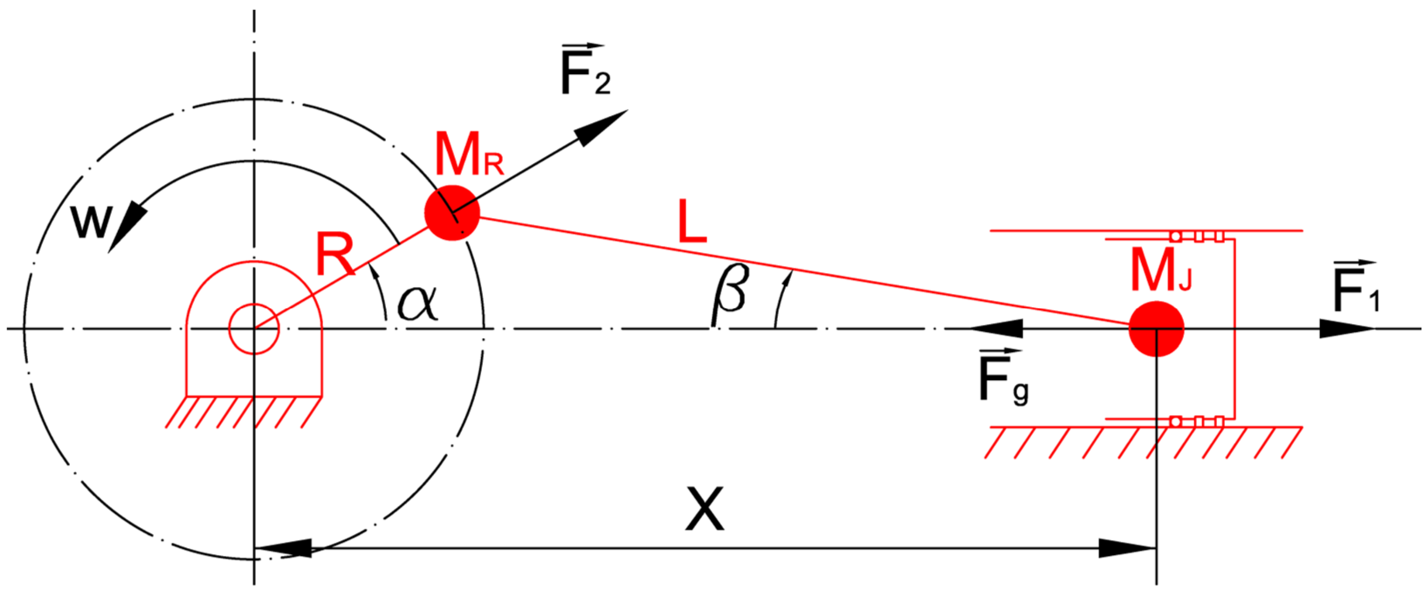
$$\overrightarrow{F_5} = 795,42 \measuredangle (170,73)^\circ \text{ N}$$

Total force acting on conrod bearing w/o balance

$$\sum \vec{F} = \vec{F_R} = \vec{F_2}\measuredangle\alpha° + \vec{F_5}\measuredangle(180-\beta) + \vec{F_3}\measuredangle(360-\beta)$$

$$\sum \vec{F} = \vec{F_R} = 27405.87\measuredangle 30° + 795.42\measuredangle(170.73) + 19015.46\measuredangle(350.73)$$

$$\sum \vec{F} = \vec{F_R} = 43083.51\measuredangle 14.477°\ N$$



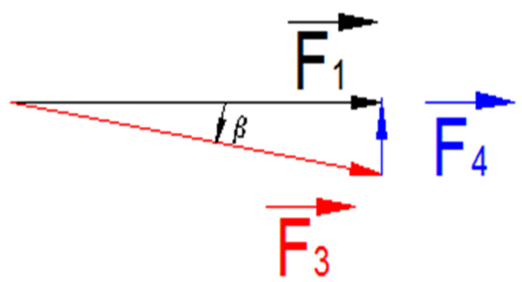
F4

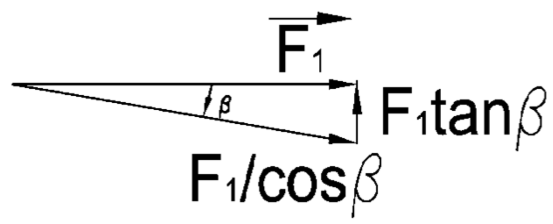
$$\overrightarrow{F_4} = \left|F_1 \tan \beta\right| \measuredangle 90° \left\{\ddot{X} < 0 \ \& \ \beta > 0\right\}$$

$$\overrightarrow{F_4} = \left|F_1 \tan \beta\right| \measuredangle 270° \left\{\ddot{X} < 0 \ \& \ \beta < 0\right\}$$

$$\overrightarrow{F_4} = \left|F_1 \tan \beta\right| \measuredangle 270° \left\{\ddot{X} > 0 \ \& \ \beta > 0\right\}$$

$$\overrightarrow{F_4} = \left|F_1 \tan \beta\right| \measuredangle 90° \left\{\ddot{X} > 0 \ \& \ \beta < 0\right\}$$

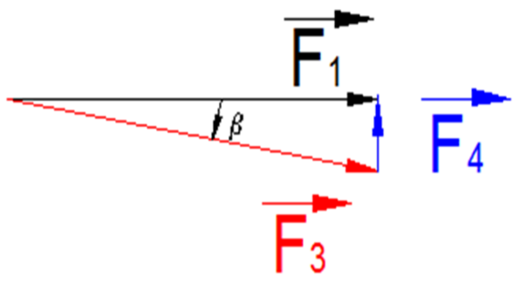


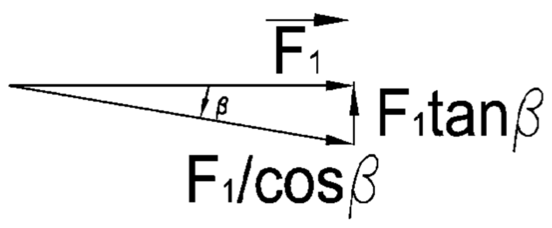


F4

$$\vec{F}_4 = \left|18766.36 \tan 9.27\right| \measuredangle 90°$$

$$\vec{F}_4 = 3063 \measuredangle 90° \text{ N}$$

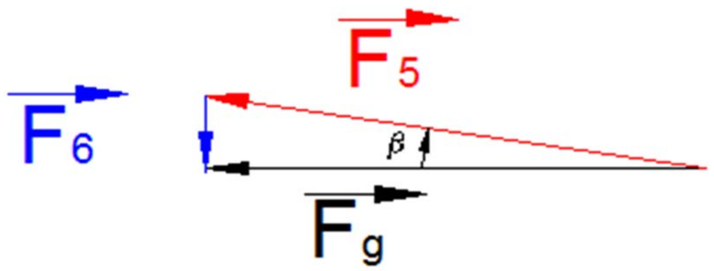


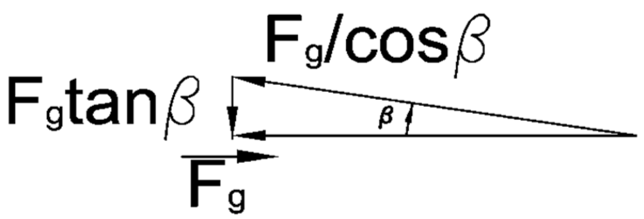


F6

$$\vec{F}_6 = \left| F_g \tan\beta \right| \measuredangle 270^\circ \left\{ \beta > 0 \right\}$$

$$\vec{F}_6 = \left| F_g \tan\beta \right| \measuredangle 90^\circ \left\{ \beta < 0 \right\}$$

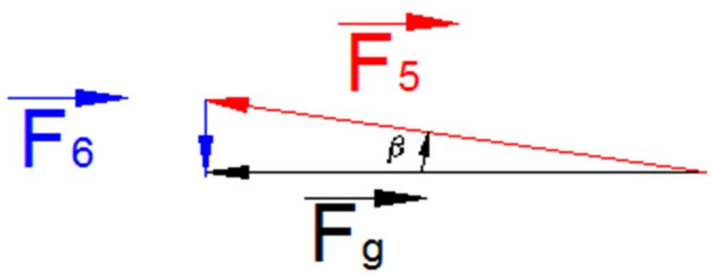


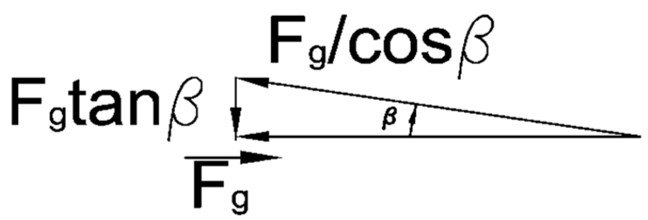


F6

$$\overrightarrow{F_6} = |785 \tan 9.27| \measuredangle 270°$$

$$\overrightarrow{F_6} = 128.12 \measuredangle 270° \ N$$





Moment created by reciprocating movement

$$X = R\cos\alpha + L\cos\beta$$

$$X = \frac{64}{1000}.\cos(30) + \frac{198.55}{1000}\cos(9.26)$$

$$X = 0.2513\,m$$

$$\sum M = X.\left[\vec{F}_4 + \vec{F}_6\right]$$

$$\sum M = 0.2513.\left[3063\measuredangle 90 + 128.12\measuredangle 270\right]$$

$$\sum M = 737.53\,Nm$$