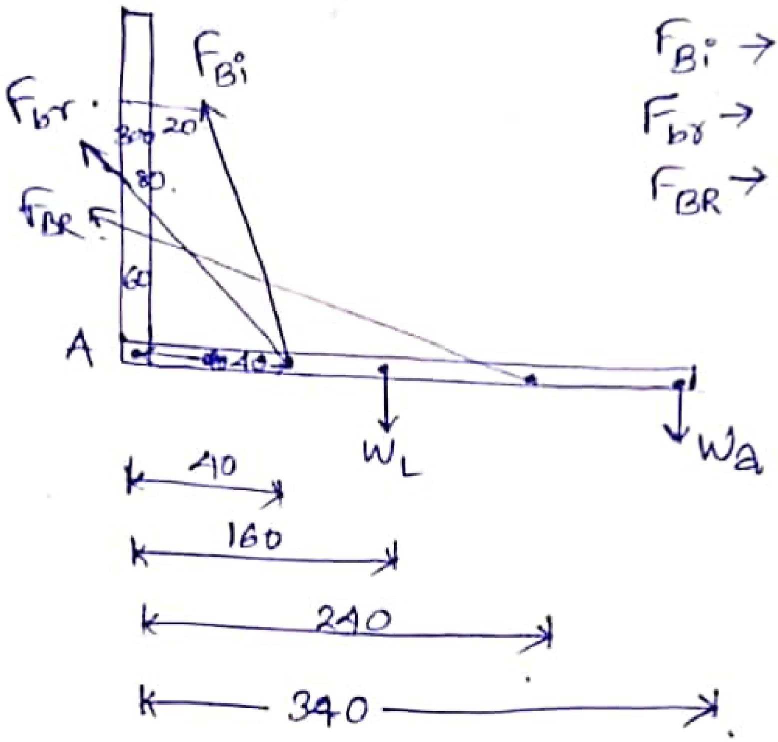
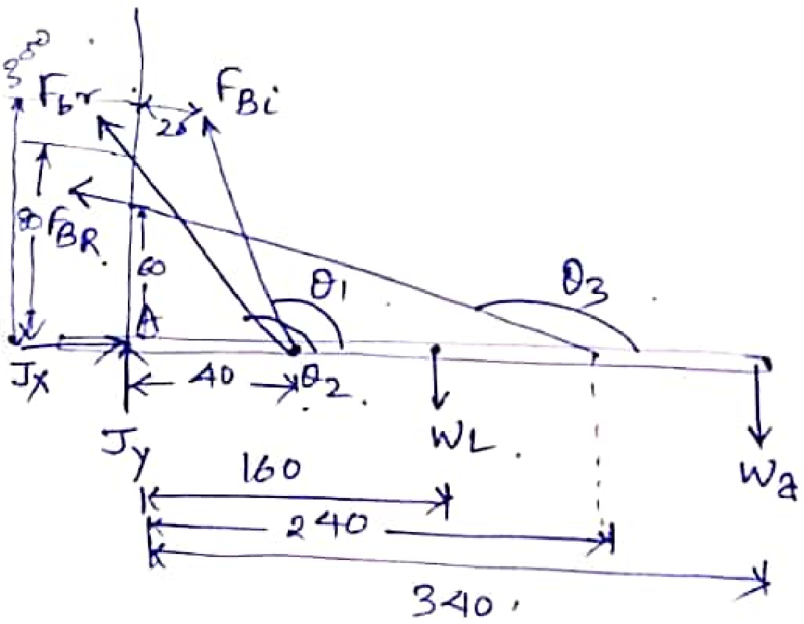
2016

$W_a \to$ Applied load.
$W_L \to$ Weight of limb.
$F_{Bi} \to$ Force on Bicep
$F_{br} \to$ Force on Brachialis
$F_{BR} \to$ " " Brachio-radialis



Free Body diagram

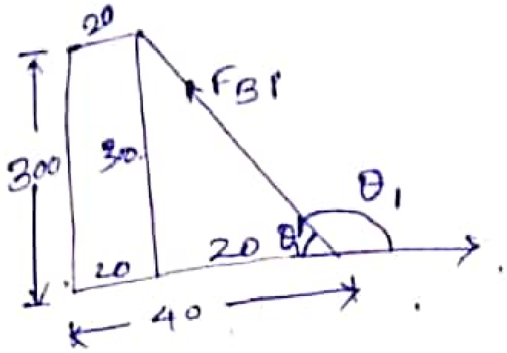


$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_A = 0$

$(-)$ $(+)$



$$\tan\theta_1' = \frac{300}{20}$$

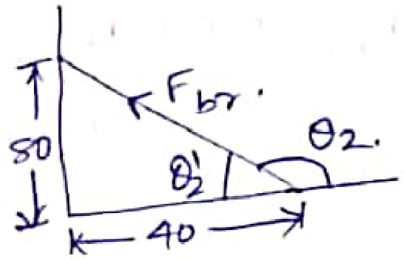
$$\Rightarrow \theta_1' = 86.1859°$$

$$\theta_1 = 180° - 86.1859°$$

$$\Rightarrow \boxed{\theta_1 = 93.8141°}$$

$$\sin\theta_1 = 0.9978$$

$$\cos\theta_1 = -0.0665$$



$$\tan\theta_2' = \frac{80}{40}$$

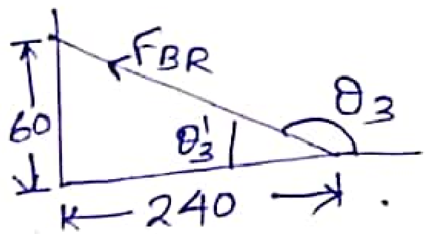
$$\Rightarrow \theta_2' = 63.4349°$$

$$\theta_2 = 180° - 63.4349°$$

$$\Rightarrow \boxed{\theta_2 = 116.5651°}$$

$$\sin\theta_2 = 0.8944$$

$$\cos\theta_2 = -0.4472$$



~~tan 30°~~

$$\tan\theta_3' = \frac{60}{240}$$

$$\Rightarrow \theta_3' = 14.0362°$$

$$\theta_3 = 180° - 14.0362°$$

$$\Rightarrow \boxed{\theta_3 = 165.9638°}$$

$$\sin\theta_3 = 0.2425$$

$$\cos\theta_3 = -0.9701$$

<u>Now</u>

$\Sigma F_x = 0$.

$\Rightarrow J_x + F_{Bi}\cos\theta_1 + F_{Br}\cos\theta_2 + F_{BR}\cos\theta_3 = 0$

$\Rightarrow J_x + F_{Bi}(-0.0665) + F_{br}(-0.4472)$
$+ F_{BR}(-0.9701) = 0$

$\Rightarrow \cancel{J_x}$
$\Rightarrow J_x - 0.0665 F_{Bi} - 0.4472 F_{br} - 0.9701 F_{BR} = 0$ —— (1).

$\Sigma F_y = 0$

$\Rightarrow J_y + F_{Bi}\sin\theta_1 + F_{br}\sin\theta_2 + F_{BR}\sin\theta_3 - W_L - W_a = 0$

$\Rightarrow J_y + 0.9978 F_{Bi} + 0.8944 F_{Br} + 0.2425 F_{BR} - W_L - W_a = 0$ —— (2).

$\Sigma M_A = 0$

$\Rightarrow F_{Bi}\sin\theta_1 \times 40 + F_{Br}\sin\theta_2 \times 40 + F_{BR}\sin\theta_3 \times 240$
$- W_L \times 160 - W_a \times 340 = 0$.

$\Rightarrow 0.9978 \times 40 \times F_{Bi} + 0.8944 \times 40 \times F_{Br} + 0.2425 \times 240 \times F_{BR}$
$- 160 W_L - 340 W_a = 0$

$\Rightarrow 39.912 F_{Bi} + 35.776 F_{Br} + 58.2 F_{BR} - 160 W_L - 340 W_a$
$= 0$ —— (3)

We have 3 equations and no. of unknowns are 5 → J_x, J_y, F_{Bi}, F_{BR}, F_{br} (Indeterminate situation)

Assume that all 3 muscles are stressed to the same intensity. Then the force produced by each muscle will be propotional to its cross-sectional area.

Given that $A_{Bi} = 500 mm^2$

$A_{br} = 480 mm^2$.

$A_{BR} = 100 mm^2$

So according to our assumption,

$$\frac{F_{Bi}}{A_{Bi}} = \frac{F_{br}}{A_{br}} = \frac{F_{BR}}{A_{BR}}.$$

$$\Rightarrow \frac{F_{Bi}}{500} = \frac{F_{br}}{480}$$

$$\Rightarrow F_{br} = 0.96 F_{Bi} \quad \text{———} \quad 4.$$

$$\frac{F_{Bi}}{500} = \frac{F_{BR}}{100}$$

$$\Rightarrow F_{BR} = 0.2 F_{Bi} \quad \text{———} \quad 5.$$

Now no. of eq^n = no. of unknowns = 5.
(determinate situation).

Rewriting the eq^n 1, 2, 3 in terms of F_{Bi} again we can find that

$$J_x - 0.0665\,F_{Bi} - 0.4472 \times 0.96 \times F_{Bi} - 0.9701 \times 0.2\,F_{Bi} = 0$$

$$\Rightarrow J_x - 0.6898\,F_{Bi} = 0 \quad \text{——— (6)}$$

$$J_y + 0.9978\,F_{Bi} + 0.8944 \times 0.96 \times F_{Bi} + 0.2425 \times 0.2 \times F_{Bi} - 25 - 120 = 0$$

$$\left(\because \begin{array}{l} W_L = 25\,N \\ W_a = 120\,N \end{array} \text{ Given}\right)$$

$$\Rightarrow J_y + 1.9049\,F_{Bi} - 145 = 0 \quad \text{——— (7)}.$$

$$39.912\,F_{Bi} + 35.776 \times 0.96\,F_{Bi} + 58.2 \times 0.2\,F_{Bi} - 160 \times 25 - 340 \times 120 = 0.$$

$$\Rightarrow 85.8969\,F_{Bi} = 44800$$

$$\Rightarrow \boxed{F_{Bi} = 521.5554\,N}$$

$$F_{br} = 0.96\,F_{Bi}$$

$$\Rightarrow F_{br} = 0.96 \times 521.5554$$

$$\Rightarrow \boxed{F_{br} = 500.6932\,N}$$

$$F_{BR} = 0.2\,F_{Bi}$$

$$\Rightarrow F_{BR} = 0.2 \times 521.5554 \Rightarrow \boxed{F_{BR} = 104.3111\,N}$$

ⓐ Force produced by each muscle

$F_{Bi} = 521.5554\ N$

$F_{B?} = 500.6932\ N$

$F_{BR} = 104.3111\ N$

Humero-radial Joint force R_R :→ Forces acting on the radius are

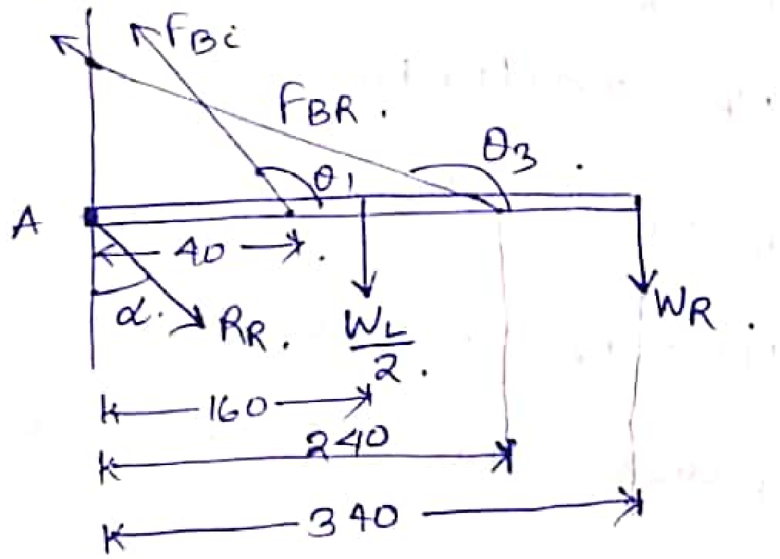
a portion of the applied load, say W_R

half of the weight of forearm ~~as~~ $\frac{W_L}{2}$

F_{BC} , F_{BR} , ~~R_B~~ R_R

Ligament forces (F_L) → which will be ignored for the first ~~stag~~ stage of calculation.

FBD



$\Sigma F_x = 0$

$\Rightarrow R_R \sin\alpha + F_{Bc}\cos\theta_1 + F_{BR}\cos\theta_3 = 0$

$\Rightarrow R_R \sin\alpha + 521.5554 \times (0.0665) + (-0.9701)104.3111 = 0$

$\Rightarrow$ ~~RB~~ $R_R \sin\alpha = 135.8756$ ——— ⑧

$\Sigma F_y = 0$

$\Rightarrow W_R + \frac{W_L}{2} + R_R\cos\alpha = F_{Bc}\sin\theta_1 + F_{BR}\sin\theta_3$

Scanned by CamScanner

$$\Rightarrow W_R + \frac{25}{2} + R_R \cos\alpha = 521.5554 \times 0.497 + 104.3111 \times 0.242$$

$$\Rightarrow W_R + R_R \cos\alpha = 533.2034 \qquad (9)$$

$\Sigma M_A = 0$.

$$\Rightarrow F_{Bi} \sin\theta_1 \times 40 + F_{BR} \sin\theta_3 \times 240 - \frac{W_L}{2} \times 160 - W_R \times 340 = 0.$$

$$\cancel{\Rightarrow \quad + \quad - 2000 - 340 W_R = 0}$$

$$\Rightarrow 340\, W_R = 24887.2251$$

$$\Rightarrow \boxed{W_R = 73.1977\ N}.$$

Putting W_R in eqⁿ (9).

$$73.1977 + R_R \cos\alpha = 533.2034$$

$$\Rightarrow R_R \cos\alpha = 460.0057 \qquad (10)$$

From eqⁿ (8) & (10).

$$\tan\alpha = \frac{135.8756}{460.0057}$$

$$\Rightarrow \boxed{\alpha = 16.4559^\circ}$$

~~Normal force R_N =~~

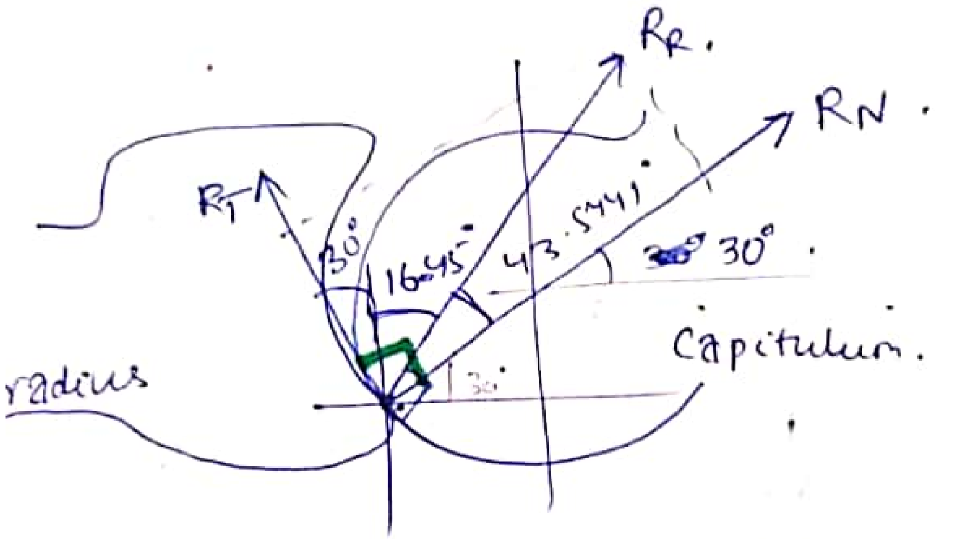
~~$R_R \cos\alpha$.~~

$R_R \cos\alpha = 460.0057$

$\Rightarrow \boxed{R_R = 479.653\,N}$

~~Normal force $R_N = R_R \cos\alpha = 460.0057\,N$~~

~~Transverse force $= R_T = R_R \sin\alpha = 135.87$~~



$R_N = R_R \cos(43.54)$
$= 347.674$

$R_T = 330.439$

Assume the interface friction coeff. $= 0.02$ (μ).

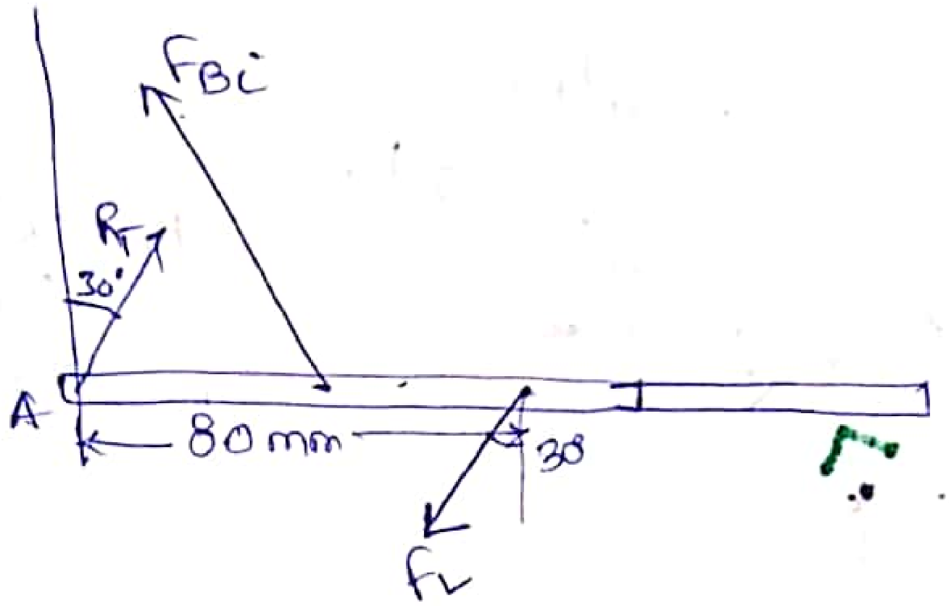
Frictional force $= \mu R_N = 0.02 \times 347.674$
$= 6.9535\,N$

So subtracting frictional force from the transeverse reaction force remainder will be 323.4855 N which will cause sliding and the radial head may be pulled away across the capitulum. But to stop this this force is absorbed by the ligaments.

The F_L & R_T will make a couple.

F_L acts 80mm from 'A'.

$F_L = 323.4855\,N$



Moment of F_L at @ 'A' $= F_L \cos 30^\circ \times 80$.

$F_L \sin 30^\circ$ $= 323.4855 \cos 30^\circ \times$

$= 22411.733$ Nmm

This moment opposes the flexion musculat and so decreases the load which can b. carried.

The moment created by applied load

$= 120 \times 340 = 40800$ Nmm.

Subtracting the Moment by F_L from the above $= 40800 - 22411.733$

$= 18388.267$ Nmm.

So the load to be carried $= \dfrac{18388.267}{340}$

$= 54.083$ N

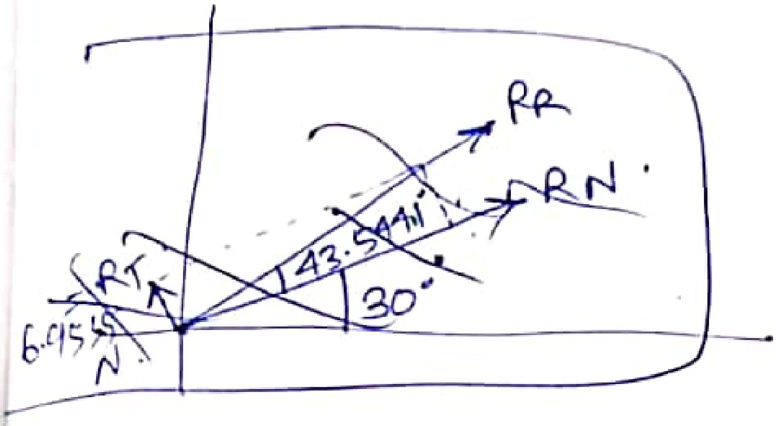
Since we are considering ligament ... now so the R_R need to be recalculated.

$R_N = 347.674\,N$ at $60°$ to Humeral axis.

R_T = sliding force = frictional force + Force carried by ligaments.

So ~~R_T~~ only frictional force $= 6.9535N$ will be there.

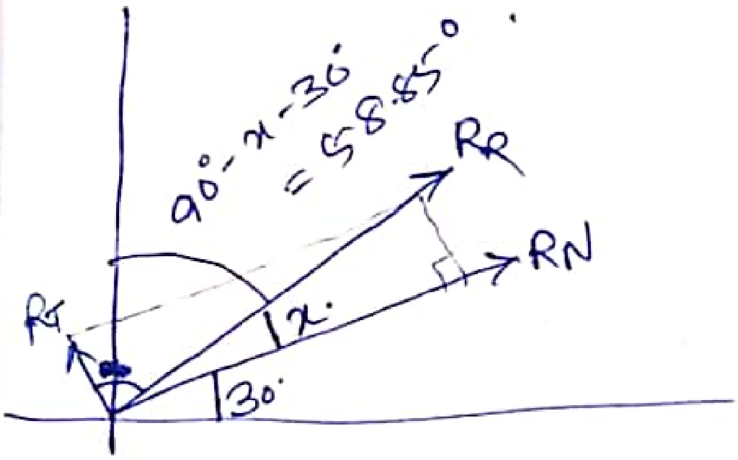
So $R_R = \sqrt{6.9535^2 + 347.674^2}$



$\Rightarrow R_R = 347.744\,N$.

~~$\tan x = \frac{R_N}{R_T}$~~.

$\tan x = \frac{R_T}{R_N}$



$\Rightarrow \tan x = \frac{6.9535}{347.674}$

$\Rightarrow x = 1.145°$.