17-05-2020

ME6230 : END-SEMESTER TAKE-HOME EXAM.

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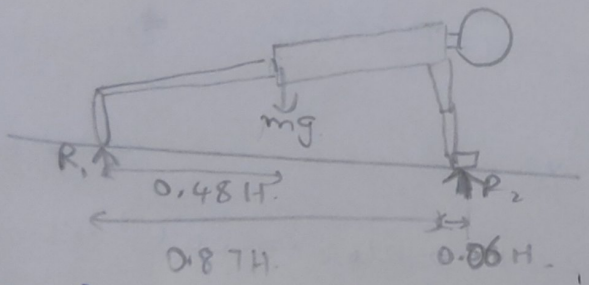
ME17B114

→ My Height : 170 cm.

→ My Weight : 86 kg.

(1.) (i.) Plank :

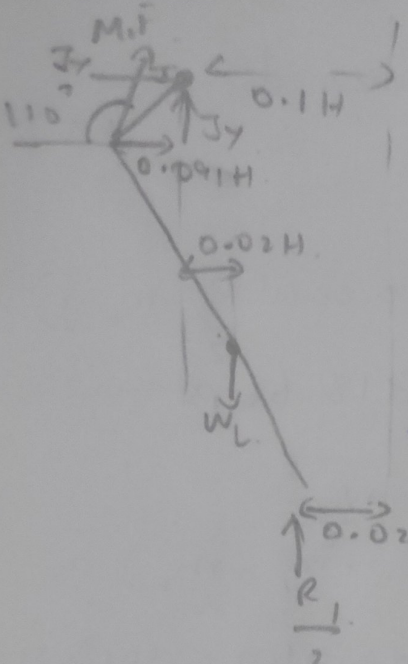


Balancing moment about foot.

$$R_2 = \frac{mg \times 0.48}{0.87 + 0.06} = 434.99\,N.$$

$$\Rightarrow R_1 = mg - 434.99\,N = 407.81\,N.$$

Hip Analysis (Plank):



$\Sigma M_J = 0$ -

$\Rightarrow MF \sin 70° \times 0.091H = W_2 \times 0.02H + \frac{R_1}{2} \times (0.191 - 0.0275)H$

$\Rightarrow M.F \times 0.07 = 334.76 \times 0.02 + \frac{407.81}{2} \times 0.1635$

$\Rightarrow M.F = 571.91 N \Rightarrow$ ~~M.R = 1048.17N. 571.91 N~~

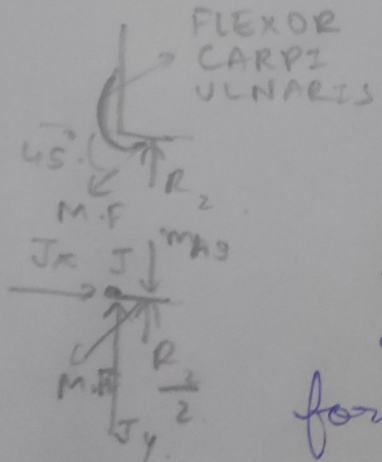
$\Sigma F_x = 0 \Rightarrow J_x = -MF\cos 70° = -362.20N$ ~~-663.83N~~

$\Sigma F_y = 0 \Rightarrow W_2 - \frac{R_1}{2} - MF\sin 70° = J_y$

$\Rightarrow J_y = 334.76 - 407.81 - 571.91 \sin 70°$

~~$\Rightarrow J_y = -884.22N$~~ $\Rightarrow J_y = -311.74$

Wrist Analysis:



Assuming flexor carpi ulnaris to be the sole stabilising muscle acting at the middle of the palm and the reaction force also acting at the middle of the palm. Assuming muscle force at 45° to palm.

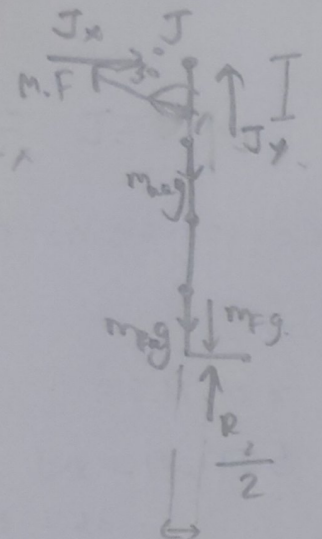
$\Sigma M_J = 0 \Rightarrow M.F \sin 45° = \frac{R_2}{2} - m_h g = \frac{R_2}{2} - 0.006mg$

$\Rightarrow M.F = \sqrt{2}(\frac{434.99}{2} - 0.006 \times 9.8 \times 86) =$ ~~608.02N~~ 300.39 N

$\Sigma F_y = 0 \Rightarrow J_y = 0$

$\Sigma F_x = 0 \Rightarrow J_x = MF\cos 45° =$ ~~429.23N~~ 212.44 N

Shoulder analysis



Assuming latissmus dorsi to stabilise the shoulder with parameters as shown in the diagram.

$\Rightarrow \sum M_J = 0 \Rightarrow MF\sin 30^\circ \times 0.08H = 0.06H\left(\frac{R_2}{2} - m_h g\right)$

$\Rightarrow MF = \cancel{644.89\,N}\ 318.66\,N$.

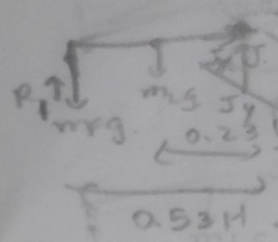
$\sum F_y = 0 \Rightarrow J_y = -\left(MF\cos 30^\circ + \frac{R_2}{2}\right) + (m_u + m_F + m_h)\,g.$

$\Rightarrow J_y = \underset{-266.65}{\cancel{-912.01}} + (0.0271 + 0.0162 + 0.006) \times 86 \times 9.8$

$\Rightarrow J_y = \underset{-266.65}{\cancel{-912.01}} + 41.38 = \cancel{-810.63\,N}\ -225.27$

$J_x = MF\sin 30^\circ = \cancel{322.45\,N}\ 159.33\,N$.

L5 Sacral Analysis:



~~In the plank position the abdominal muscles are the major stabilisers~~ assuming the erector spinae to act.

$$M.F \times 0.02H = +R_1 \times 0.53H.$$

In the plank position assuming the abdominal muscles to be the major stabilisers

$$R_1 = (m_f + m_L) \times 0.53H + m_L \times 0.23H) \times g.$$

$$\Rightarrow M.F \times 0.02H = +407.81 \times 0.53H + \left[\left(\frac{1.37 \times 2}{100} \times 0.53\right) + \left(\frac{(14.16+4.33)\times 2}{100} \times 0.23\right)\right] \times 86 \times 9.8 \times H.$$

$$\Rightarrow M.F \times 0.02 = -0.1 \times 86 \times 9.8 + 216.14.$$

$$\Rightarrow M.F = 6593N.$$

$$\Sigma F_x = 0 \Rightarrow J_x + M.F\cos 45^\circ = 0.$$

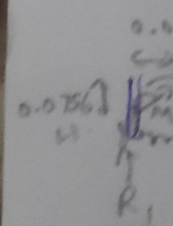
$$\Rightarrow J_x = -\frac{6593}{\sqrt{2}} = -4661.96N.$$

$$\Sigma F_y = 0 \Rightarrow J_y + M.F\sin 45^\circ + R_1 = (m_L + m_F)g.$$

$$\Rightarrow J_y + 4661.96 + 407.81 = \frac{(14.16+4.33+1.37)\times 2\times 86\times 9.8}{100}$$

$$\Rightarrow J_y = 334.76 - 407.81 - 4661.96 = -4735.01N$$

Ankle Analysis:



$$\Sigma M_J = 0.$$

$$\Rightarrow M.F(\cos 45^\circ \times 0.0756H - \sin 45^\circ \times 0.01H) = \left(\frac{R_1}{2} - m_F g\right) \times 0.01H.$$

$$\Rightarrow M.F \times 0.046 = \left(\frac{407.81}{2} - \frac{1.37}{100} \times 86 \times 9.8\right) \times 0.01$$

$$\Rightarrow M.F = 41.82N$$

$\Sigma F_x = 0 \Rightarrow J_x = -MF\cos45^\circ = -60.91.32N$. $-29.57N$

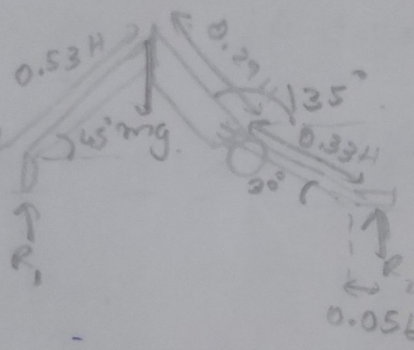
$\Sigma F_y = 0 \Rightarrow J_y = m_f g - \frac{R_1}{2} - MF\sin45^\circ$.

$= \frac{1.37}{100} \times 86 \times 9.8 - \frac{407.81}{2} - \frac{86.14}{\sqrt{2}}$ 29.57

$= 482.4074$ $-221.93\ N$.

(ii) Dog-facing ground posture:

Assuming the posture to have the following values with references from slides anthropometric data & online photos



Balancing moment about foot:

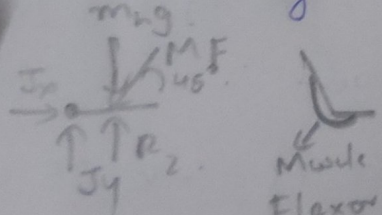
$\Rightarrow mg \times 0.53H \times \cos45^\circ = R_2 \times [0.53H\cos45^\circ + 0.29H\cos45^\circ + 0.33H\cos30^\circ + 0.056H]$

$\Rightarrow R_2 = \frac{86 \times 9.8 \times 0.53}{0.922 \times \sqrt{2}}$

$= 342.72\ N$.

$\Rightarrow R_1 = mg - R_2 = 500.08N$.

Wrist Analysis: All assumptions valid as per the wrist analysis in the plank post.



$\Sigma M_J = 0 \Rightarrow MF\sin45^\circ = \frac{R_2}{2} - m_h g$.

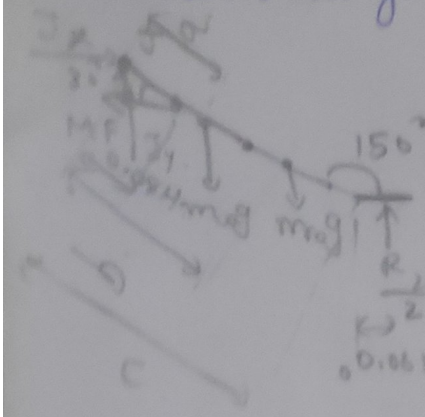
$\Rightarrow MF = \sqrt{2}(342.72/2 - 0.006 \times 9.8 \times 86)$

$\Rightarrow MF = 4\cancel{17.53N}$ $235.19N$.

$\Sigma F_y = 0 \Rightarrow J_y = 0$.

$\Sigma F_x = 0 \Rightarrow J_x = MF\cos45^\circ = \cancel{337.66N}$ $166.30N$.

Shoulder Analysis: Carrying forward the same assumptions from shoulder analysis in plank posture



$$a = \frac{57.72}{100} \times 0.186H = 0.107H$$

$$b = 0.186H + \frac{45.74}{100} \times 0.146H = 0.253H$$

$$c = 0.186H + 0.146H = 0.332H$$

$$\Sigma M_J = 0 \Rightarrow m_{ua}g \times a\cos 30^\circ + m_{Fa}g \times b\cos 30^\circ + MF\sin 30^\circ \times 0.08H = \frac{R_2}{2}(c\cos 30^\circ + 0.06H)$$

$$\Rightarrow \left(0.0271 \times 0.107 \times \frac{\sqrt{3}}{2} + 0.0162 \times 0.253 \times \frac{\sqrt{3}}{2}\right) \times 86 \times 9.8 + MF \times 0.04 = \frac{342.72}{2}\left(0.332 \times \frac{\sqrt{3}}{2} + 0.06\right)$$

$$\Rightarrow MF = \frac{-5.11 + 59.55}{0.04} = 1361.03\,N$$

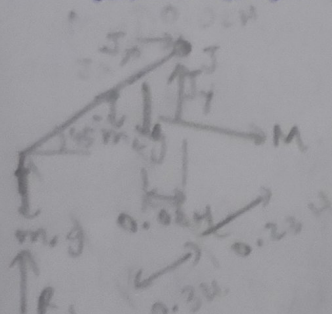
$$\Sigma F_x = 0 \Rightarrow J_x = MF = 1361.03\,N$$

$$\Sigma F_y = 0 \Rightarrow J_y = (m_{ua} + m_{Fa})g - \frac{R_2}{2}$$

$$= (0.0271 + 0.0162) \times 9.8 \times 86 - \frac{342.72}{2}$$

$$\Rightarrow J_y = -134.87\,N$$

L-5 Sacral Analysis:



Going with the same assumptions for the sacral analysis in the plank part.

$$\Sigma M_J \Rightarrow MF \times 0.02H + m_L g \times 0.23 \times \cos 45^\circ + m_C g \times 0.53 \times \cos 45^\circ = R_1 \times 0.53 \times \cos 45^\circ$$

$$\Rightarrow M.F = \frac{500.08 \times 0.53 - \left(\frac{1.37 \times 2}{100} \times 0.53 + \frac{(14.16 + 4.33) \times 0.23}{100}\right) \times 86 \times 9.8}{\sqrt{2} \times 0.02}$$

$$= 6403.55\,N$$

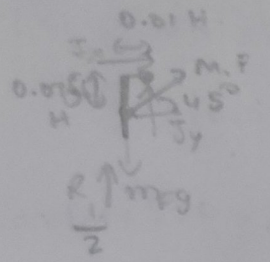
$\Sigma F_x = 0 \Rightarrow J_x = 0.$

$\Sigma F_y = 0 \Rightarrow J_y = M.F + (m_L + m_F)g - R_1$

$\Rightarrow J_y = 6403.55 + \frac{(14.16 + 4.33 + 1.37)}{100} \times 2 \times 86 \times 9.8 - 500.08$

$= 6238.23 N.$

Ankle Analysis:



$\Sigma M_J = 0.$

$M.F\,(\cos 45^\circ \times 0.075 - \sin 45^\circ \times 0.01 H) = (\frac{R_1}{2} - m_f g) \times 0.01$ H-1

$\Rightarrow M.F \times 0.046 = \left(\frac{500.08}{2} - \frac{1.37}{100} \times 86 \times 9.8\right) \times 0.01$

$\Rightarrow M.F = 51.85 N.$

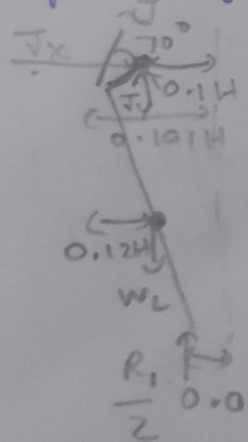
$J_x = -MF\cos 45^\circ = -36.66 N$

$J_y = m_f g - \frac{R_1}{2} - MF\sin 45^\circ.$

$= \frac{1.37}{100} \times 86 \times 9.8 - \frac{500.08}{2} - \frac{51.85}{\sqrt{2}}$

$\Rightarrow J_y = -275.16 N$

Hip Analysis:



$\Sigma M_J = 0$

$\Rightarrow M.F \sin 70^\circ \times 0.091H = W_L \times 0.02H + R_1 \times (0.191 - 0.0275H)$

$\Rightarrow M.F \times 0.07 = 334.76 \times 0.02 + \frac{500.08}{2}(0.16)$

$\Rightarrow M.F = 667.16 N.$

$\Sigma F_x = 0 \Rightarrow J_x = -MF\cos 70^\circ = -422.53 N$

$\Sigma F_y = 0 \Rightarrow J_y = W_L - R_1/2 - MF\sin 70^\circ$

$= 334.76 - \frac{500.08}{2} - 667.16 \sin 70^\circ$

$\Rightarrow J_y = -431.59 N.$