17-05-2020

ME6230 : END-SEMESTER TAKE-HOME EXAM.

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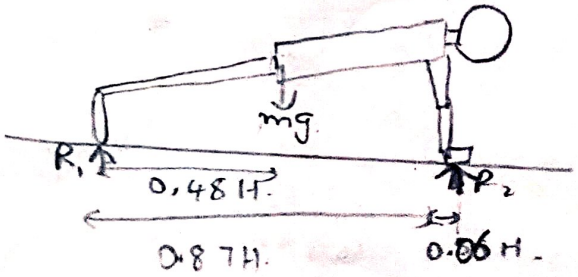
ME17B114

→ My Height : 170 cm.

→ My Weight : 86 kg.

(1.) (i) Plank:

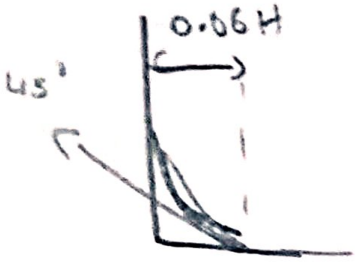


Balancing moment about foot.

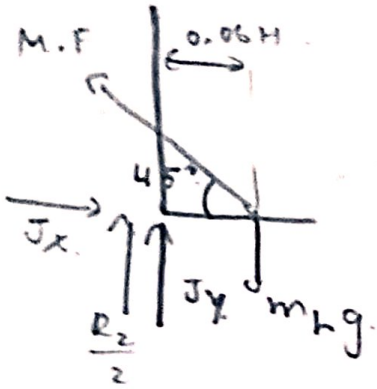
$$R_2 = \frac{mg \times 0.48}{0.87 + 0.06} = 434.99\,N.$$

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

Wrist Analysis



Assuming extensor carpi ulnaris to be the sole stabilising muscle acting at the middle of the palm where weight of the hand acts and the ~~reaction~~ reaction force to act directly under the wrist axis. Also assume muscle force to be at 45° to ground.



$\Rightarrow \Sigma M_J = 0 \Rightarrow MF \sin 45^\circ = m_h g = 0.006\,mg.$

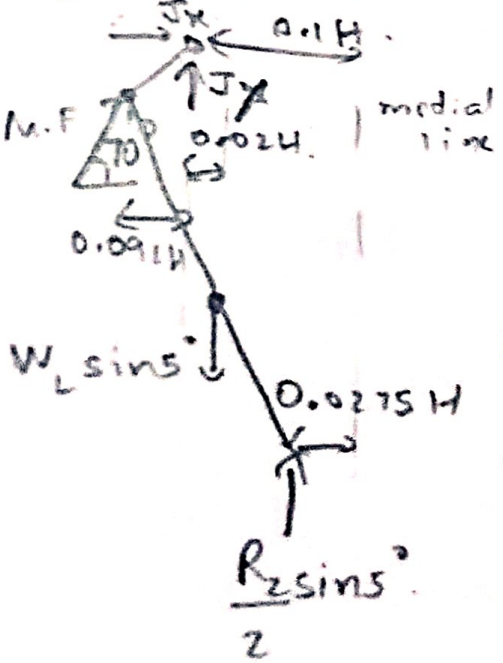
$\Rightarrow MF = 7.15\,N.$

$\Sigma F_y = 0 \Rightarrow J_y = -\frac{R_2}{2} = 217.49\,N.$

$\Sigma F_x = 0 \Rightarrow J_x = MF \cos 45^\circ = 5.05\,N.$

Hip Analysis:

Assuming the sole acting muscle to be gluteus medius. All the reaction and weights ~~act~~ have only a small component in the leg hip plane. Assuming the leg to ground angle to be 5° the ~~cos~~ sin component is $\sin 5^\circ$. Assuming muscle insertion angle: 70°



$\Sigma M_J = 0$

$\Rightarrow MF \sin 70^\circ \times 0.091H = \sin 5^\circ \times \left(W_L \times 0.02H + \frac{R_1}{2} \times (0.191H - 0.0275H) \right)$

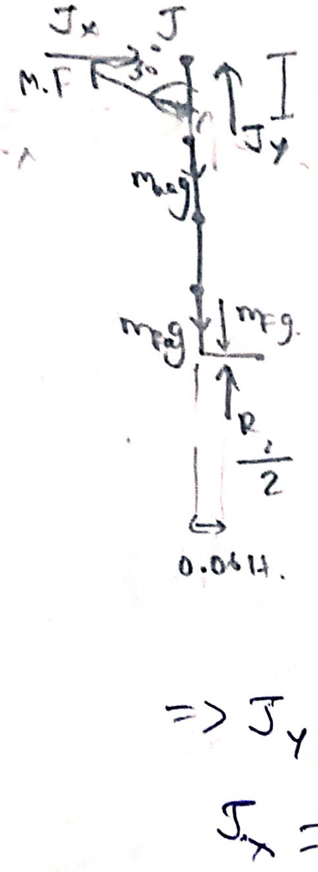
$\Rightarrow M.F = 49.85\,N.$

$\Sigma F_x = 0 \Rightarrow J_x = -M.F \cos 70^\circ = -17.05\,N$

$\Sigma F_y = 0 \Rightarrow J_y = \left(W_L - \frac{R_1}{2} \right) \times \sin 5^\circ - M.F \sin 70^\circ$

$\Rightarrow J_y = -38.45\,N.$

Shoulder analysis



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

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

$\Rightarrow MF =$ ~~644.89 N~~ ~~318.66 N~~ 159.33

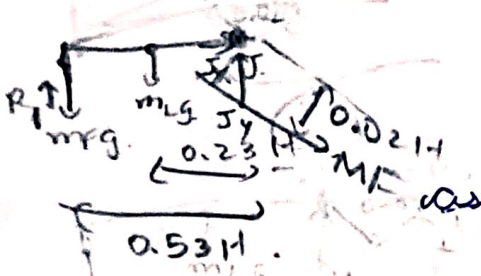
$\Sigma F_y = 0 \Rightarrow J_y = -\left(MF\cos 30° + \frac{R_2}{2}\right) + (m_u + m_F + m_h)\, g.$

$\Rightarrow J_y =$ ~~−912.04~~ −266.65 + (0.0271 + 0.0162 + 0.006) × 86 × 9.8

$\Rightarrow J_y =$ ~~−912.04~~ ~~−266.65~~ −355.48 + 41.38 = ~~−870.63 N~~ ~~−225.27~~ −314.09

$J_x = MF\sin 30° =$ ~~322.45 N~~ ~~159.33 N~~ 79.665 N.

L-5 Sacral Analysis:



In the plank position the ~~abdominal muscles are the major stabilizers~~ 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 stabilizers

$\Rightarrow M.F \times 0.02H = +(m_f \times 0.53H + m_L \times 0.23H) \times g.$

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

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

$\Rightarrow M.F = 6593N.$

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

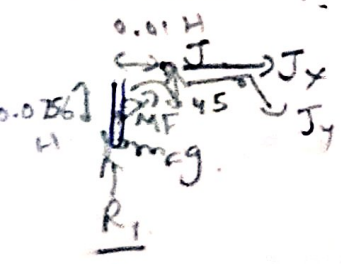
$\Rightarrow J_x = -\frac{6593}{\sqrt{2}} = -4661.96N.$

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

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

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

Ankle Analysis: (The muscle is soleus).



$\Sigma M_J = 0.$

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

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

$\Rightarrow M.F = 41.82N.$

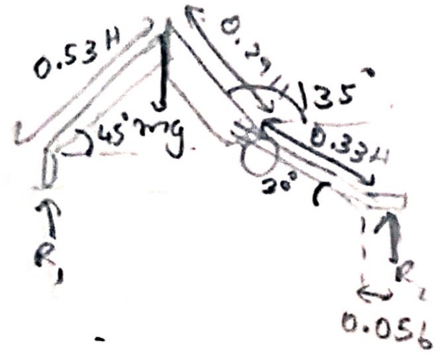
$\Sigma F_x = 0 \Rightarrow J_x = -M.F\cos 45° = $ ~~-60.91~~ $-29.57N$

$\Sigma F_y = 0 \Rightarrow J_y = m_f g - \frac{R_1}{2} - MF\sin 45°$.

$= \frac{1.37 \times 86 \times 9.8}{100} - \frac{407.81}{2} - \frac{29.57}{\sqrt{2}}$ (~~86.~~)

$=$ ~~-482.407~~ $-221.93\ N$.

(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:

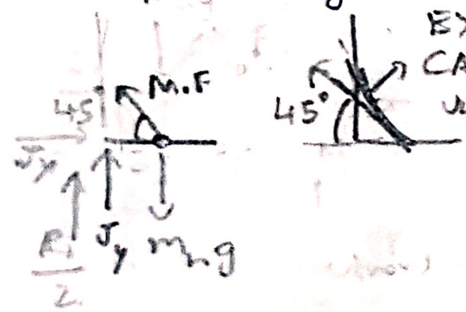
$\Rightarrow mg \times 0.53H \times \cos 45° = R_2 \times [0.53H\cos 45° + 0.29H\cos 45° + 0.33H\cos 30° + 0.056H]$

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

$= 342.72N$.

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

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



$\Sigma M_J = 0 \Rightarrow MF\sin 45° = \frac{R}{2} + m_h g$.

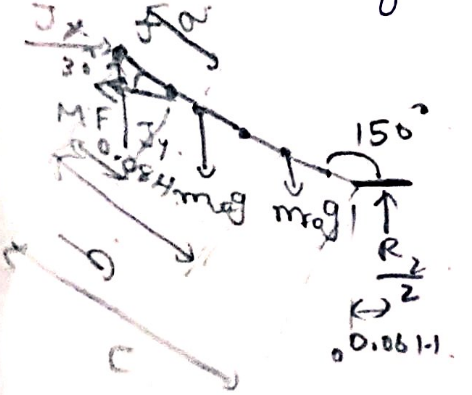
$\Rightarrow MF = \sqrt{2}($ ~~342.72/2~~ $0.006 \times 9.8 \times 86)$

$\Rightarrow MF =$ ~~417.53N~~ ~~235.~~ $7.15\ N$.

$\Sigma F_y = 0 \Rightarrow J_y = $ ~~0~~ $-\frac{R_1}{2} = -171.36$

$\Sigma F_x = 0 \Rightarrow J_x = MF\cos 45° = $ ~~337.~~ ~~166.~~
$= 5.06N$.

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



$a = \frac{57.72 \times 0.186H}{100} = 0.1074.$

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

$C = 0.186H + 0.146H = 0.332H.$

$\Sigma M_J = 0 \Rightarrow m_{ua} g \times a\cos 30^\circ + m_{fa} g \times b\cos 30^\circ + MF \sin 30^\circ \times 0.08H$

$= \frac{R_2}{2}(c\cos 30^\circ + 0.06H)$

$\Rightarrow \left(0.0271 \times 0.107 \times \frac{\sqrt{3}}{2} + 0.0162 \times 0.253 \times \frac{\sqrt{3}}{2}\right) \times 86 \times 9.8 + MF \times 0.0$

$= \frac{342.72}{2}\left(0.332 \times \frac{\sqrt{3}}{2} + 0.06\right)$

$\Rightarrow MF = \frac{-5.11 + ~~112.10~~\ 59.55}{0.04} = ~~2849.81~~\ 1361.03N.$

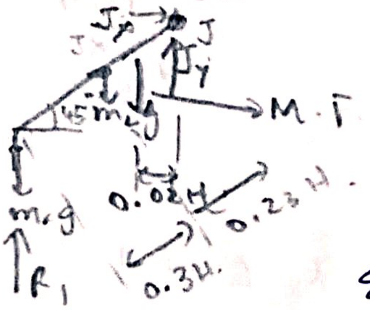
$\Sigma F_x = 0 \Rightarrow J_x = MF = ~~2849.81~~\ 1361.03\,N.$

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

$= (0.0271 + ~~0.1074~~\ 0.0162) \times 9.8 \times 86 - \frac{342.72}{2}$

$\Rightarrow J_y = -~~302.23N~~\ -134.87N.$

L-5 Sacral Analysis:



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

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

$\Rightarrow M.F = \frac{500.08 \times 0.53 - \left(\frac{1.37 \times 2 \times 0.53}{100} + \frac{(14.16 + 4.33) \times 2 \times .23}{100}\right) \times 86 \times 9.8}{\sqrt{2} \times 0.02}$

$= ~~128.03N~~\ 6403.55N$

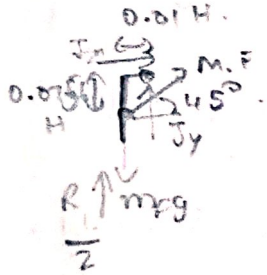
$\Sigma F_x = 0 \Rightarrow J_x = 0.$

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

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

$= 6238.23 N.$

Ankle Analysis: The muscle is solew.



$\Sigma M_J = 0.$

$M.F\,(\cos 45^\circ \times 0.075 H - \sin 45^\circ \times 0.01 H)$

$= (\frac{R_1}{2} - m_F g) \times 0.01 H$

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

$\Rightarrow M.F = 51.85 N.$

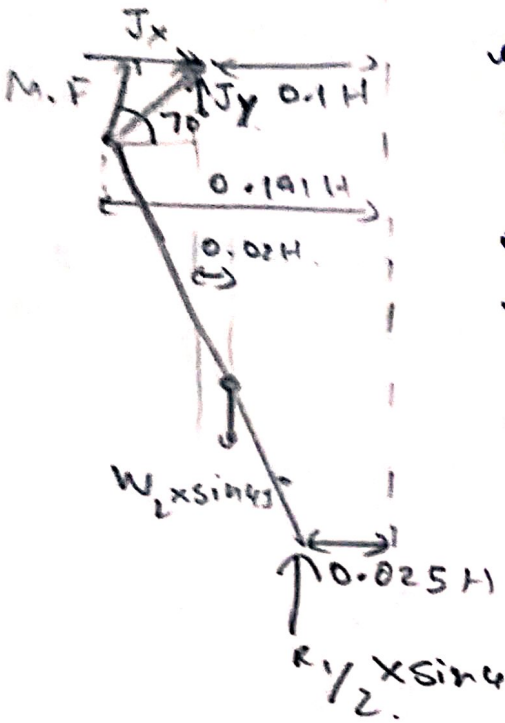
$J_x = -MF\cos 45^\circ = -36.66 N$

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

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

$\Rightarrow J_y = -275.16 N$

Hip Analysis:



All the assumption of the hip analysis carry forward from the plank position to hear except for the weight and reaction force component which happens to be $\sin 45°$. This higher component will have a significant impact as you can see below:

$$\Sigma M_J = 0$$

$$\Rightarrow MF \sin 70° \times 0.091H = \sin 45° \times \left(W_L \times 0.02H + R_1 \times (0.191 - 0.275H) \right)$$

$$\Rightarrow M.F \times 0.07 = \frac{1}{\sqrt{2}} \left(334.76 \times 0.02 + \frac{500.08}{2} (0.16) \right)$$

$$\Rightarrow M.F = 471.78\,N.$$

$$\Sigma F_x = 0 \Rightarrow J_x = -M.F \cos 70° = -161.35\,N$$

$$J_y = \sin 45° \left(W_L - \frac{R_1}{2} \right) - M.F \sin 70°$$

$$= -383.4\,N.$$