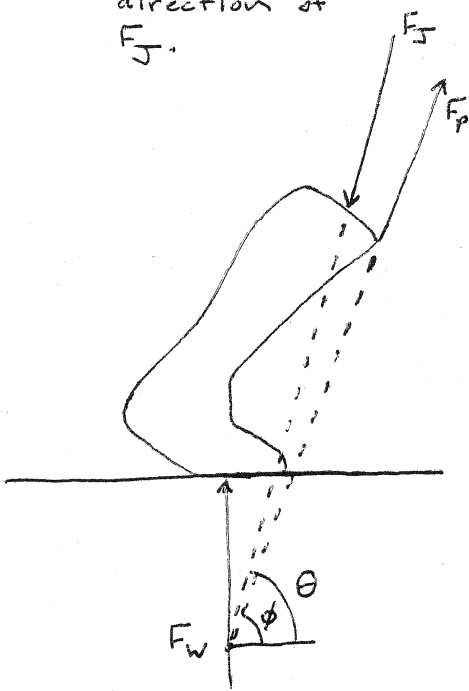
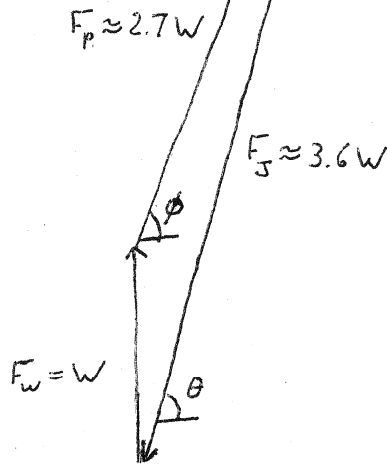


Find point of concurrency to determine the direction of F_J .



Use a vector diagram to estimate the magnitude of F_J and F_P .



2.2

$$\sum M_H = I_H \alpha$$

$$(I_{HAT})_{Hip} \alpha = T_H - d_{HAT} m_{HAT} g$$

$$T_H = (I_{HAT})_{Hip} \alpha + d_{HAT} m_{HAT} g$$

$$(I_{HAT})_{Hip} = (k_{HAT})_{Hip}^2 m_{HAT}$$

$$(k_{HAT})_{Hip} = .621 \times .52 \times 1.8 = 0.581 \text{ m}, \quad m_{HAT} = .678 \times 70 = 47.46 \text{ kg}$$

$$d_{HAT} = .374 \times .52 \times 1.8 = .350 \text{ m}$$

$$(I_{HAT})_{Hip} = .581^2 \times 47.46 = 16.02 \text{ kg} \cdot \text{m}^2$$

$$T_H = 16.02 \times 3 + .350 \times 47.46 \times 9.81 = 48.1 + 162.9 = 211.0 \text{ N} \cdot \text{m}$$

2-3

About the hip

$$\sum M_H = I_H \alpha$$

$$T_H - m_T g d_T - m_{LL} g (d_{LL} + l_T) = (I_T + I_{LL})_H \alpha$$

$$(I_{LL})_H = (I_{LL})_{cm} + (l_T + d_{LL})^2 m_{LL}$$

$$T_H = ((I_T)_H + (I_{LL})_{cm} + (l_T + d_{LL})^2 m_{LL}) \alpha + m_T g d_T + m_{LL} g (d_{LL} + l_T)$$

$$T_H = (.4 + .05 + 5(.40 + .20)^2)(2) + (8)(9.81)(.18) + (5)(9.81)(.20 + .40)$$

$$T_H = 48 \text{ N} \cdot \text{m}$$

For the lower leg

$$\sum F_y = m_{LL} (a_{LL})_y$$

$$F_{Ky} - m_{LL} a_G = m_{LL} (l_T + d_{LL}) \alpha$$

$$F_{Ky} = m_{LL} (l_T + d_{LL}) \alpha + m_{LL} a_G$$

$$F_{Ky} = 5(.4 + .2)(2) + 5(9.81)$$

$$F_{Ky} = 55 \text{ N}$$

About the mass center of the lower leg

$$\sum M_{GL} = I_{GL} \alpha = T_K - d_{LL} F_{Ky}$$

$$T_K = I_{GL} \alpha + d_{LL} F_{Ky}$$

$$T_K = 5(2) + .2(55)$$

$$T_K = 11 \text{ N} \cdot \text{m}$$

2-4

About the hip

$$\sum M_H = I_H \alpha$$

$$T_H + m_T d_T (a_T - a_G) + m_{LL} (l_T + d_{LL}) (a_{LL} - a_G) = (I_T + I_{LL})_H \alpha$$

$$a_T = \alpha d_T \quad a_{LL} = a_K = \alpha l_T$$

$$(I_{LL})_H = (I_{LL})_{cm} + m_{LL} (l_T + d_{LL})^2$$

$$T_H = [I_T + (I_{LL})_{cm} + m_{LL} (l_T + d_{LL})^2] \alpha - m_T d_T (\alpha d_T - a_G) - m_{LL} (l_T + d_{LL}) (\alpha l_T - a_G)$$

$$T_H = [.4 + .05 + 5(.4 + .2)^2](3) - (8)(.18)[(3)(.18) - 9.81] - 5(.4 + .2)[(3)(.4) - 9.81]$$

$$T_H = 46 \text{ N} \cdot \text{m}$$

For the lower leg

$$\sum F_y = m_{LL} (a_{LL})_y \quad a_K = \alpha l_T$$

$$F_{Ky} = m_{LL} \alpha l_T + m_{LL} a_G = m_{LL} (\alpha l_T + a_G)$$

$$F_{Ky} = 5[3(.4) + 9.81]$$

$$F_{Ky} = 55 \text{ N}$$

About the mass center of the lower leg

$$\sum M_{GL} = I_{GL} \alpha = T_K - d_{LL} F_{Ky}$$

$$T_K = I_{GL} \alpha + d_{LL} F_{Ky}$$

$$T_K = .05(3) + .2(55)$$

$$T_K = 11 \text{ N} \cdot \text{m}$$

2.5

moments about the shoulder

$$M_S - m_L g d_L - (m_h + m_b) g (L_L + d_h) = \sum I_{cm} \alpha + \left| \vec{d} \times m \vec{r} \right|$$

RHS of the equation

$$(I_u + I_L) \alpha + d_u m_u a_u + m_L a_L \sqrt{L_u^2 + d_L^2} + (m_h + m_b) a_h \sqrt{L_u^2 + (L_L + d_h)^2}$$

$$a_u = d_u \alpha \quad a_L = \alpha \sqrt{L_u^2 + d_L^2} \quad a_h = \alpha \sqrt{L_u^2 + (L_L + d_h)^2}$$

$$(I_u + I_L) \alpha + d_u^2 m_u \alpha + (L_u^2 + d_L^2) m_L \alpha + (L_u^2 + (L_L + d_h)^2) (m_h + m_b) \alpha$$

solving for the moment

$$M_S = m_L g d_L + (m_h + m_b) g (L_L + d_h) + \alpha \left[I_u + I_L + d_u^2 m_u + (L_u^2 + d_L^2) m_L + (L_u^2 + (L_L + d_h)^2) (m_h + m_b) \right]$$

substituting values yields

$$M_S = 12.02 \text{ N} \cdot \text{m}$$

moments about the elbow

$$M_E - m_L g d_L - (m_h + m_b) g (L_L + d_h) = \sum I_{cm} \alpha + \left| \vec{d} \times m \vec{r} \right|$$

$$M_E - m_L g d_L - (m_h + m_b) g (L_L + d_h) = d_L^2 m_L \alpha + (L_L + d_h)^2 (m_h + m_b) \alpha$$

$$M_E = m_L g d_L + (m_h + m_b) g (L_L + d_h) + d_L^2 m_L \alpha + (L_L + d_h)^2 (m_h + m_b) \alpha$$

substituting values yields

$$M_E = 10.66 \text{ N} \cdot \text{m}$$

2-6

$$T_h = [(I_T)_H + (I_{LL})_H] \alpha$$

$$(I_T)_H = (I_T)_{GT} + m_T d_T^2 = 4.2 + .045(8)^2 = 7.08 \text{ lb} \cdot \text{sec}^2 \cdot \text{in}$$

$$(I_{LL})_H = (I_{LL})_{GL} + m_{LL} (l_T + d_{LL})^2 = 1.4 + .025(18+8)^2 = 18.3 \text{ lb} \cdot \text{sec}^2 \cdot \text{in}$$

$$T_H = (7.08 + 18.3) \times 20 = 507.6 \text{ in} \cdot \text{lb}$$

$$\sum F_x = m_{LL} \ddot{x}_{ll} = F_{Kx}; \quad \sum F_y = m_{LL} \ddot{y}_{ll} = F_{Ky} - m_{LL} g$$

$$\ddot{x}_{ll} = (l_T + d_{LL}) \alpha = (18 + 8) \times 20 = 520 \frac{\text{in}}{\text{sec}^2}; \quad \ddot{y}_{ll} = 0$$

$$F_{Kx} = m_{LL} \ddot{x}_{ll} (1) = .025 \times 520 = 13 \text{ lbf}$$

$$\sum M_{GL} = (I_{LL})_{GL} \ddot{\theta}_{LL} = T_K - a_{LL} F_{Kx}$$

$$T_K = (I_{LL})_{GL} \ddot{\theta}_{LL} + d_{LL} F_{Kx} = 1.4 \times 20 + 8 \times 13 = 132 \text{ in} \cdot \text{lb}$$

2.7

$$T_H = (I_T)_{GT} \alpha + (d_T) m_T a_{GTx} + (l_T + d_{LL}) m_{LL} a_{GLx}$$

$$T_H = (I_T)_{GT} \alpha + (d_T)^2 m_T \alpha + (l_T + d_{LL})(l_T) m_{LL} \alpha$$

$$T_H = [(I_T)_{GT} + (d_T)^2 m_T + (l_T + d_{LL})(l_T) m_{LL}] \alpha$$

$$T_H = [4.2 + (8)^2 (.045) + (18 + 8)(18)(.025)] 20 = 376 \text{ in} \cdot \text{lb}$$

For the lower leg

$$\sum F_y = m_{LL} (a_{LL})_y \quad a_K = \alpha l_T$$

$$F_{Ky} = m_{LL} \alpha l_T + m_{LL} a_G = m_{LL} (\alpha l_T + a_G)$$

$$F_{Ky} = .025 [20(18) + 9.81]$$

$$F_{Ky} = 9.25 \text{ lbf}$$

About the mass center of the lower leg

$$\sum M_{GL} = I_{GL} \alpha = T_K - d_{LL} F_{Ky}$$

$$T_K = I_{GL} \alpha + d_{LL} F_{Ky}$$

$$T_K = 1.4(20) + 8(9.25)$$

$$T_K = 102 \text{ lb} \cdot \text{in}$$

2-8

By forward difference approximation

$$v_{x1}(t) = \frac{x_1(t + \Delta t) - x_1(t)}{\Delta t}$$

Apply the above to calculate v_{x2}, v_{y1}, v_{y2}

$$\vec{\omega} = \frac{\vec{v}}{\vec{r}}$$

$$\omega(t) = \frac{\sqrt{(v_{x2}(t) - v_{x1}(t))^2 + (v_{y2}(t) - v_{y1}(t))^2}}{\sqrt{(x_2(t) - x_1(t))^2 + (y_2(t) - y_1(t))^2}}$$

$$\alpha(t) = \frac{\omega(t + \Delta t) - \omega(t)}{\Delta t}$$

t, s	x ₁ , cm	y ₁ , cm	x ₂ , cm	y ₂ , cm	v _{x1} , cm/s	v _{y1} , cm/s	v _{x2} , cm/s	v _{y2} , cm/s	ω, rad/s	α, rad/s ²
0.0	131.8	6.1	162.6	6.9	8.0	1.0	-23.0	68.0	2.396	1.987
0.1	132.6	6.2	160.3	13.7	-2.0	-3.0	-21.0	69.0	2.595	3.110
0.2	132.4	5.9	158.2	20.6	-6.0	-7.0	-52.0	66.0	2.906	-8.699
0.3	131.8	5.2	153.0	27.2	-4.0	4.0	-54.0	41.0	2.036	
0.4	131.4	5.6	147.6	31.3						