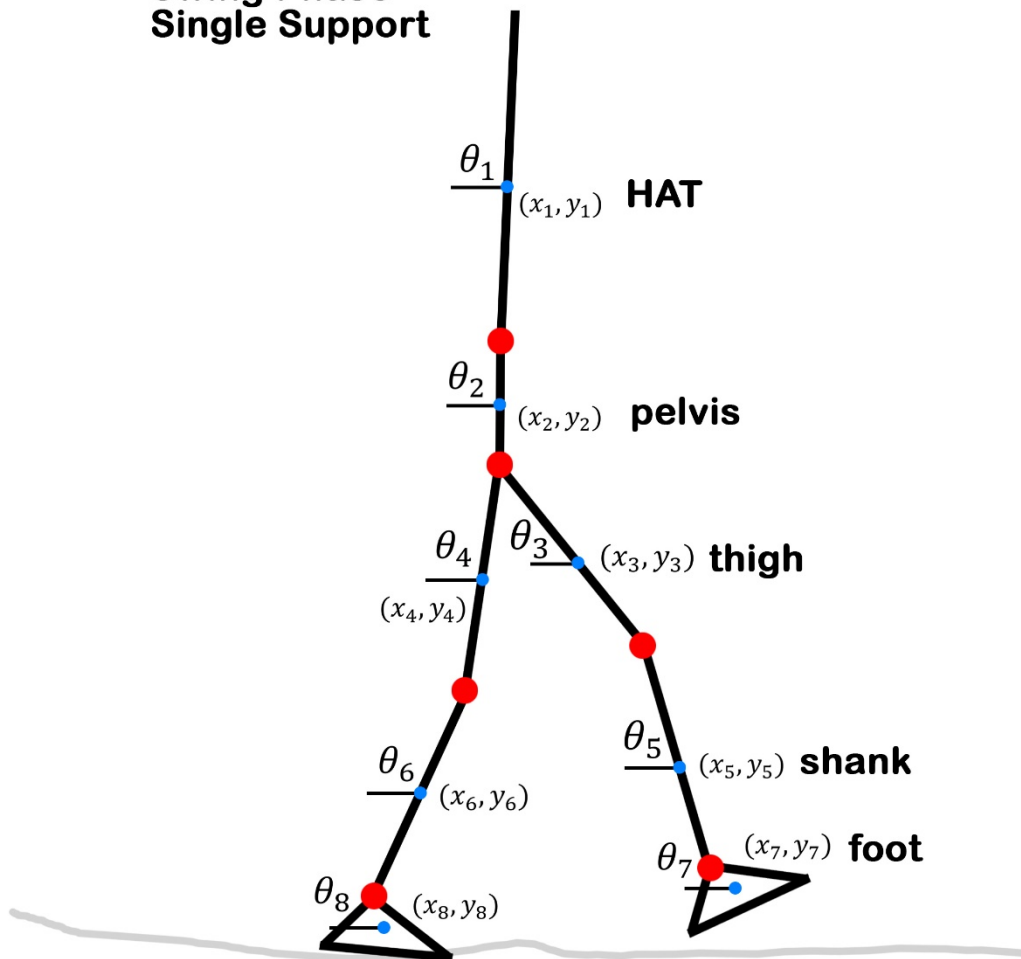
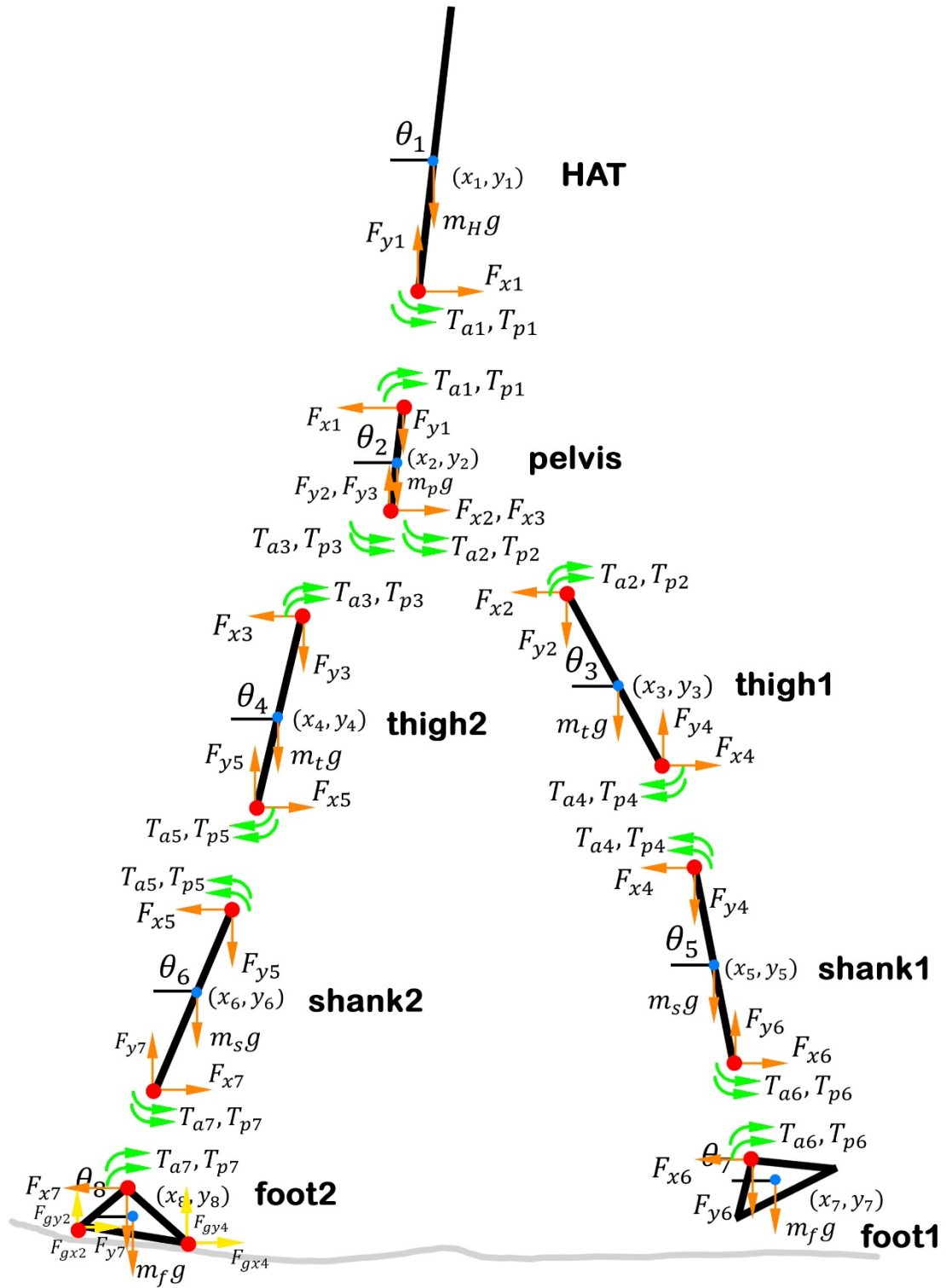


**Stage 6
Swing Phase
Single Support**



Stage 6



Stage 6

HAT:

$$\begin{aligned}m_H \ddot{x}_1 &= F_{x1} \\m_H \ddot{y}_1 &= F_{y1} - m_H g \\I_H \ddot{\theta}_1 &= -F_{x1} l_{H2} \sin \theta_1 - F_{y1} l_{H2} \cos \theta_1 - T_{p1} - T_{a1}\end{aligned}$$

Pelvis:

$$\begin{aligned}m_p \ddot{x}_2 &= -F_{x1} + F_{x2} + F_{x3} \\m_p \ddot{y}_2 &= -F_{y1} + F_{y2} + F_{y3} - m_p g \\I_p \ddot{\theta}_2 &= -F_{x1} l_p \sin \theta_2 - F_{y1} l_p \cos \theta_2 - F_{x2} l_p \sin \theta_2 - F_{y2} l_p \cos \theta_2 - F_{x3} l_p \sin \theta_2 - F_{y3} l_p \cos \theta_2 + T_{p1} \\&\quad - T_{p2} - T_{p3} + T_{a1} - T_{a2} - T_{a3}\end{aligned}$$

Thigh1:

$$\begin{aligned}m_t \ddot{x}_3 &= -F_{x2} + F_{x4} \\m_t \ddot{y}_3 &= -F_{y2} + F_{y4} - m_t g \\I_t \ddot{\theta}_3 &= -F_{x2} l_t \sin \theta_3 - F_{y2} l_t \cos \theta_3 - F_{x4} l_t \sin \theta_3 - F_{y4} l_t \cos \theta_3 + T_{p2} + T_{p4} + T_{a2} + T_{a4}\end{aligned}$$

Thigh2:

$$\begin{aligned}m_t \ddot{x}_4 &= -F_{x3} + F_{x5} \\m_t \ddot{y}_4 &= -F_{y3} + F_{y5} - m_t g \\I_t \ddot{\theta}_4 &= -F_{x3} l_t \sin \theta_4 - F_{y3} l_t \cos \theta_4 - F_{x5} l_t \sin \theta_4 - F_{y5} l_t \cos \theta_4 + T_{p3} + T_{p5} + T_{a3} + T_{a5}\end{aligned}$$

Shank1:

$$\begin{aligned}m_s \ddot{x}_5 &= -F_{x4} + F_{x6} \\m_s \ddot{y}_5 &= -F_{y4} + F_{y6} - m_s g \\I_s \ddot{\theta}_5 &= -F_{x4} l_s \sin \theta_5 - F_{y4} l_s \cos \theta_5 - F_{x6} l_s \sin \theta_5 - F_{y6} l_s \cos \theta_5 - T_{p4} - T_{p6} - T_{a4} - T_{a6}\end{aligned}$$

Shank2:

$$\begin{aligned}m_s \ddot{x}_6 &= -F_{x5} + F_{x7} \\m_s \ddot{y}_6 &= -F_{y5} + F_{y7} - m_s g \\I_s \ddot{\theta}_6 &= -F_{x5} l_s \sin \theta_6 - F_{y5} l_s \cos \theta_6 - F_{x7} l_s \sin \theta_6 - F_{y7} l_s \cos \theta_6 - T_{p5} - T_{p7} - T_{a5} - T_{a7}\end{aligned}$$

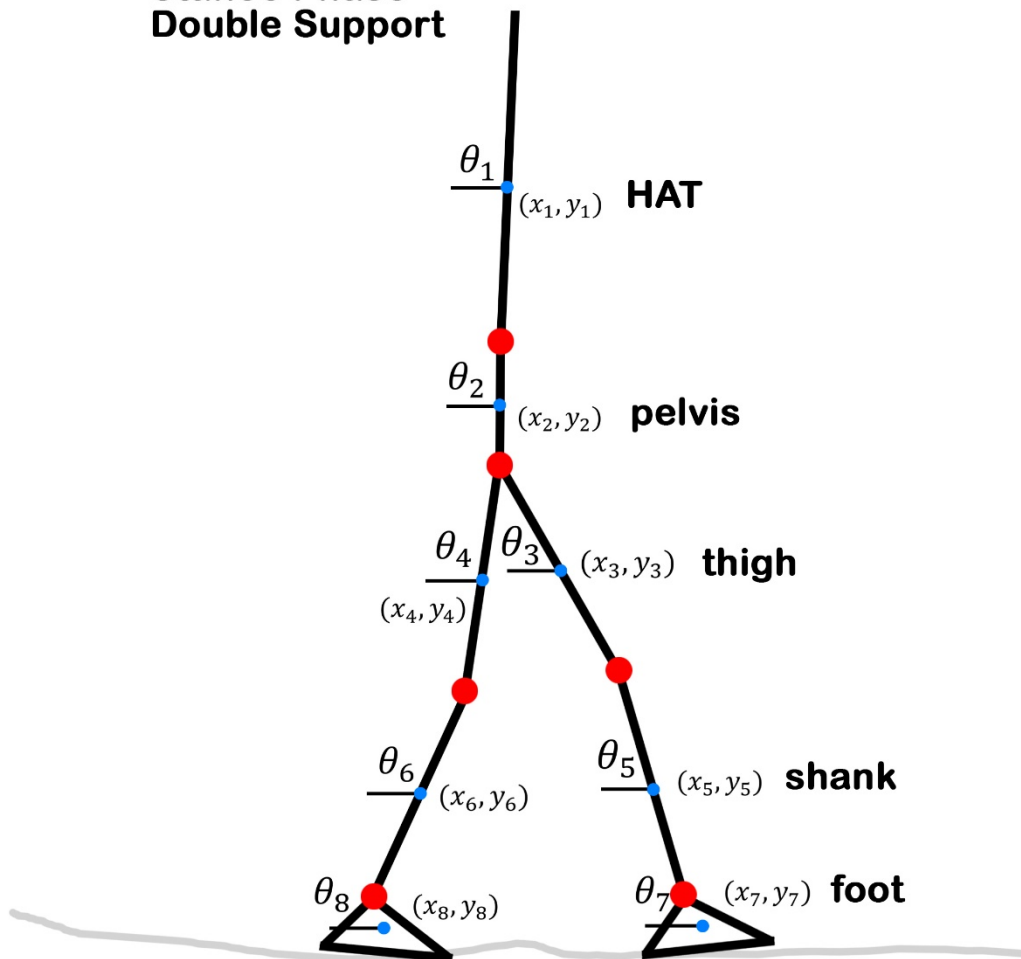
Foot1:

$$\begin{aligned}m_f \ddot{x}_7 &= -F_{x6} \\m_f \ddot{y}_7 &= -F_{y6} - m_f g \\I_f \ddot{\theta}_7 &= -F_{x6} l_{f1} \sin \theta_7 - F_{y6} l_{f1} \cos \theta_7 + T_{p6} + T_{a6}\end{aligned}$$

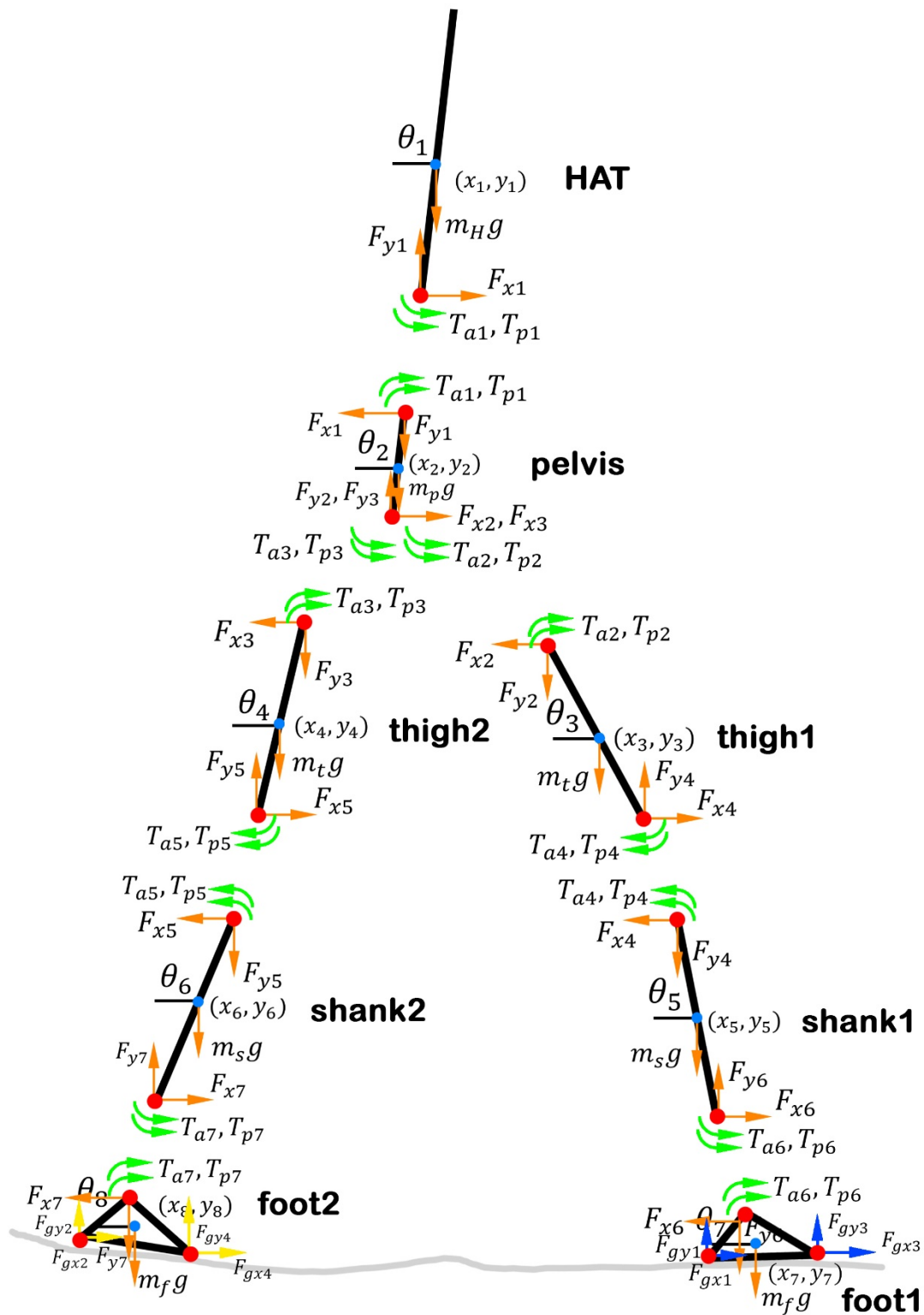
Foot2:

$$\begin{aligned}m_f \ddot{x}_8 &= -F_{x7} + F_{gx2} + F_{gx4} \\m_f \ddot{y}_8 &= -F_{y7} + F_{gy2} + F_{gy4} - m_f g \\I_f \ddot{\theta}_8 &= -F_{x7} l_{f1} \sin \theta_8 - F_{y7} l_{f1} \cos \theta_8 - F_{gx2} l_{f2} \sin(\alpha_1 - \theta_8) + F_{gy2} l_{f2} \cos(\alpha_1 - \theta_8) \\&\quad + F_{gx4} l_{f3} \sin(\alpha_2 + \theta_8) + F_{gy4} l_{f3} \cos(\alpha_2 + \theta_8) + T_{p7} + T_{a7}\end{aligned}$$

Stage 1
Stance Phase
Double Support



Stage 1



Stage 1

HAT:

$$\begin{aligned}m_H \ddot{x}_1 &= F_{x1} \\m_H \ddot{y}_1 &= F_{y1} - m_H g \\I_H \ddot{\theta}_1 &= -F_{x1} l_{H2} \sin \theta_1 - F_{y1} l_{H2} \cos \theta_1 - T_{p1} - T_{a1}\end{aligned}$$

Pelvis:

$$\begin{aligned}m_p \ddot{x}_2 &= -F_{x1} + F_{x2} + F_{x3} \\m_p \ddot{y}_2 &= -F_{y1} + F_{y2} + F_{y3} - m_p g \\I_p \ddot{\theta}_2 &= -F_{x1} l_p \sin \theta_2 - F_{y1} l_p \cos \theta_2 - F_{x2} l_p \sin \theta_2 - F_{y2} l_p \cos \theta_2 - F_{x3} l_p \sin \theta_2 - F_{y3} l_p \cos \theta_2 + T_{p1} \\&\quad - T_{p2} - T_{p3} + T_{a1} - T_{a2} - T_{a3}\end{aligned}$$

Thigh1:

$$\begin{aligned}m_t \ddot{x}_3 &= -F_{x2} + F_{x4} \\m_t \ddot{y}_3 &= -F_{y2} + F_{y4} - m_t g \\I_t \ddot{\theta}_3 &= -F_{x2} l_t \sin \theta_3 - F_{y2} l_t \cos \theta_3 - F_{x4} l_t \sin \theta_3 - F_{y4} l_t \cos \theta_3 + T_{p2} + T_{p4} + T_{a2} + T_{a4}\end{aligned}$$

Thigh2:

$$\begin{aligned}m_t \ddot{x}_4 &= -F_{x3} + F_{x5} \\m_t \ddot{y}_4 &= -F_{y3} + F_{y5} - m_t g \\I_t \ddot{\theta}_4 &= -F_{x3} l_t \sin \theta_4 - F_{y3} l_t \cos \theta_4 - F_{x5} l_t \sin \theta_4 - F_{y5} l_t \cos \theta_4 + T_{p3} + T_{p5} + T_{a3} + T_{a5}\end{aligned}$$

Shank1:

$$\begin{aligned}m_s \ddot{x}_5 &= -F_{x4} + F_{x6} \\m_s \ddot{y}_5 &= -F_{y4} + F_{y6} - m_s g \\I_s \ddot{\theta}_5 &= -F_{x4} l_s \sin \theta_5 - F_{y4} l_s \cos \theta_5 - F_{x6} l_s \sin \theta_5 - F_{y6} l_s \cos \theta_5 - T_{p4} - T_{p6} - T_{a4} - T_{a6}\end{aligned}$$

Shank2:

$$\begin{aligned}m_s \ddot{x}_6 &= -F_{x5} + F_{x7} \\m_s \ddot{y}_6 &= -F_{y5} + F_{y7} - m_s g \\I_s \ddot{\theta}_6 &= -F_{x5} l_s \sin \theta_6 - F_{y5} l_s \cos \theta_6 - F_{x7} l_s \sin \theta_6 - F_{y7} l_s \cos \theta_6 - T_{p5} - T_{p7} - T_{a5} - T_{a7}\end{aligned}$$

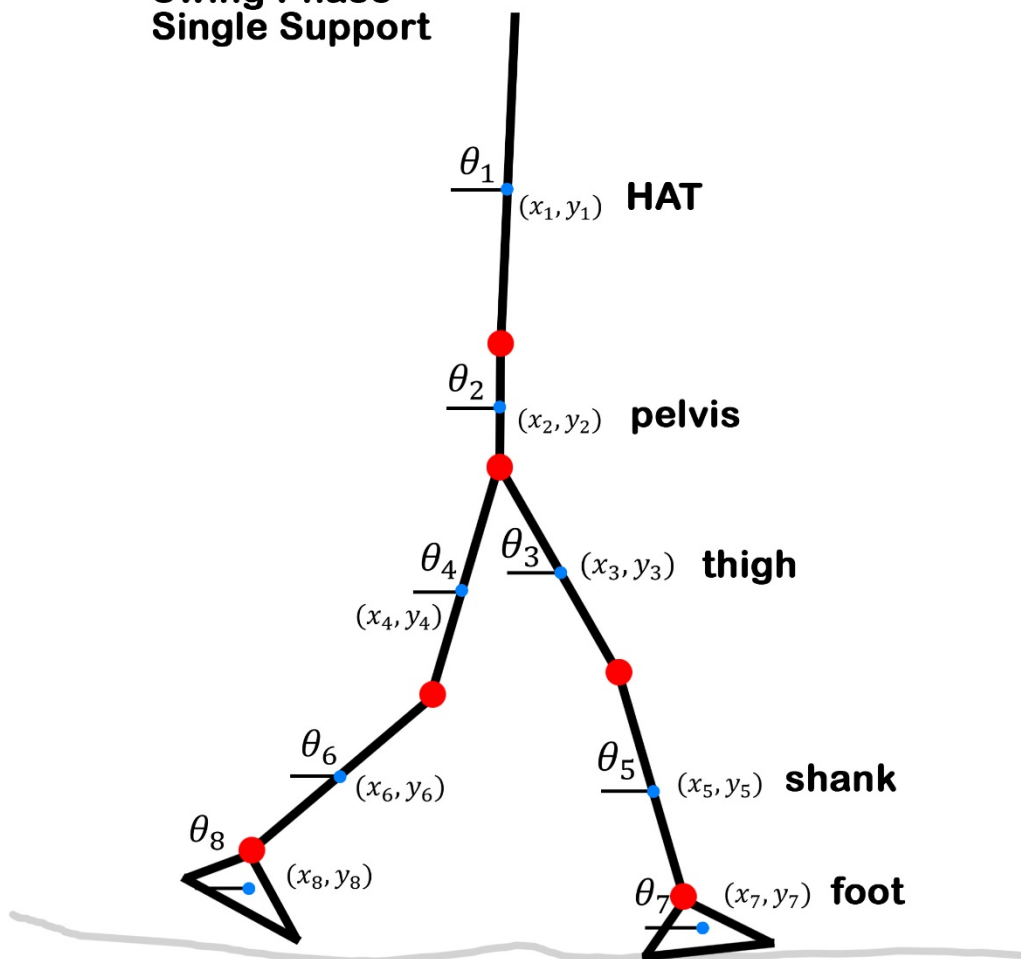
Foot1:

$$\begin{aligned}m_f \ddot{x}_7 &= -F_{x6} + F_{gx1} + F_{gx3} \\m_f \ddot{y}_7 &= -F_{y6} + F_{gy1} + F_{gy3} - m_f g \\I_f \ddot{\theta}_7 &= -F_{x6} l_{f1} \sin \theta_7 - F_{y6} l_{f1} \cos \theta_7 - F_{gx1} l_{f2} \sin(\alpha_1 - \theta_8) + F_{gy1} l_{f2} \cos(\alpha_1 - \theta_8) \\&\quad + F_{gx3} l_{f3} \sin(\alpha_2 + \theta_8) + F_{gy3} l_{f3} \cos(\alpha_2 + \theta_8) + T_{p6} + T_{a6}\end{aligned}$$

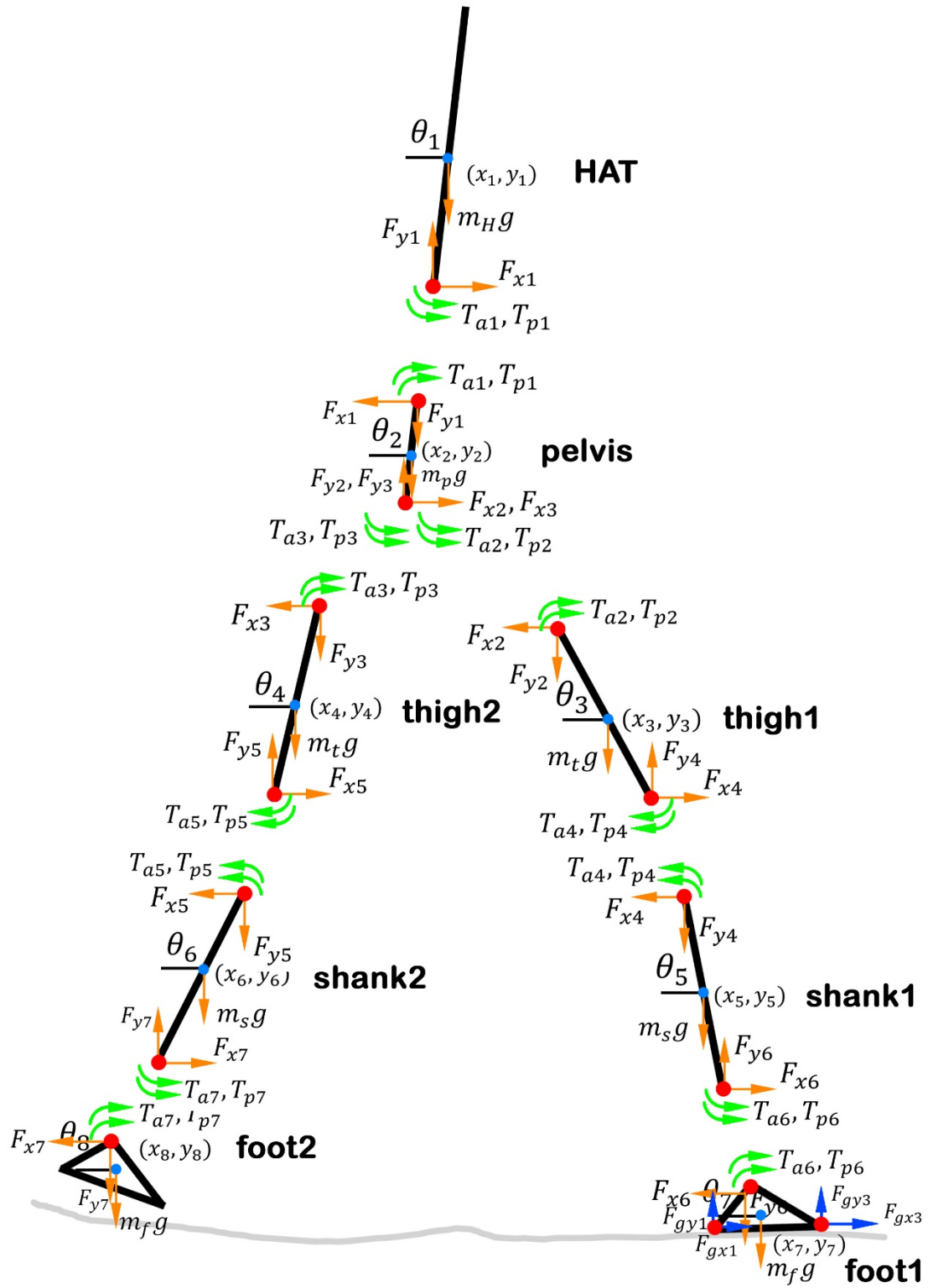
Foot2:

$$\begin{aligned}m_f \ddot{x}_8 &= -F_{x7} + F_{gx2} + F_{gx4} \\m_f \ddot{y}_8 &= -F_{y7} + F_{gy2} + F_{gy4} - m_f g \\I_f \ddot{\theta}_8 &= -F_{x7} l_{f1} \sin \theta_8 - F_{y7} l_{f1} \cos \theta_8 - F_{gx2} l_{f2} \sin(\alpha_1 - \theta_8) + F_{gy2} l_{f2} \cos(\alpha_1 - \theta_8) \\&\quad + F_{gx4} l_{f3} \sin(\alpha_2 + \theta_8) + F_{gy4} l_{f3} \cos(\alpha_2 + \theta_8) + T_{p7} + T_{a7}\end{aligned}$$

**Stage 2
Swing Phase
Single Support**



Stage 2



Stage 2

HAT:

$$\begin{aligned}m_H \ddot{x}_1 &= F_{x1} \\m_H \ddot{y}_1 &= F_{y1} - m_H g \\I_H \ddot{\theta}_1 &= -F_{x1} l_{H2} \sin \theta_1 - F_{y1} l_{H2} \cos \theta_1 - T_{p1} - T_{a1}\end{aligned}$$

Pelvis:

$$\begin{aligned}m_p \ddot{x}_2 &= -F_{x1} + F_{x2} + F_{x3} \\m_p \ddot{y}_2 &= -F_{y1} + F_{y2} + F_{y3} - m_p g \\I_p \ddot{\theta}_2 &= -F_{x1} l_p \sin \theta_2 - F_{y1} l_p \cos \theta_2 - F_{x2} l_p \sin \theta_2 - F_{y2} l_p \cos \theta_2 - F_{x3} l_p \sin \theta_2 - F_{y3} l_p \cos \theta_2 + T_{p1} \\&\quad - T_{p2} - T_{p3} + T_{a1} - T_{a2} - T_{a3}\end{aligned}$$

Thigh1:

$$\begin{aligned}m_t \ddot{x}_3 &= -F_{x2} + F_{x4} \\m_t \ddot{y}_3 &= -F_{y2} + F_{y4} - m_t g \\I_t \ddot{\theta}_3 &= -F_{x2} l_t \sin \theta_3 - F_{y2} l_t \cos \theta_3 - F_{x4} l_t \sin \theta_3 - F_{y4} l_t \cos \theta_3 + T_{p2} + T_{p4} + T_{a2} + T_{a4}\end{aligned}$$

Thigh2:

$$\begin{aligned}m_t \ddot{x}_4 &= -F_{x3} + F_{x5} \\m_t \ddot{y}_4 &= -F_{y3} + F_{y5} - m_t g \\I_t \ddot{\theta}_4 &= -F_{x3} l_t \sin \theta_4 - F_{y3} l_t \cos \theta_4 - F_{x5} l_t \sin \theta_4 - F_{y5} l_t \cos \theta_4 + T_{p3} + T_{p5} + T_{a3} + T_{a5}\end{aligned}$$

Shank1:

$$\begin{aligned}m_s \ddot{x}_5 &= -F_{x4} + F_{x6} \\m_s \ddot{y}_5 &= -F_{y4} + F_{y6} - m_s g \\I_s \ddot{\theta}_5 &= -F_{x4} l_s \sin \theta_5 - F_{y4} l_s \cos \theta_5 - F_{x6} l_s \sin \theta_5 - F_{y6} l_s \cos \theta_5 - T_{p4} - T_{p6} - T_{a4} - T_{a6}\end{aligned}$$

Shank2:

$$\begin{aligned}m_s \ddot{x}_6 &= -F_{x5} + F_{x7} \\m_s \ddot{y}_6 &= -F_{y5} + F_{y7} - m_s g \\I_s \ddot{\theta}_6 &= -F_{x5} l_s \sin \theta_6 - F_{y5} l_s \cos \theta_6 - F_{x7} l_s \sin \theta_6 - F_{y7} l_s \cos \theta_6 - T_{p5} - T_{p7} - T_{a5} - T_{a7}\end{aligned}$$

Foot1:

$$\begin{aligned}m_f \ddot{x}_7 &= -F_{x6} + F_{gx1} + F_{gx3} \\m_f \ddot{y}_7 &= -F_{y6} + F_{gy1} + F_{gy3} - m_f g \\I_f \ddot{\theta}_7 &= -F_{x6} l_{f1} \sin \theta_7 - F_{y6} l_{f1} \cos \theta_7 - F_{gx1} l_{f2} \sin(\alpha_1 - \theta_8) + F_{gy1} l_{f2} \cos(\alpha_1 - \theta_8) \\&\quad + F_{gx3} l_{f3} \sin(\alpha_2 + \theta_8) + F_{gy3} l_{f3} \cos(\alpha_2 + \theta_8) + T_{p6} + T_{a6}\end{aligned}$$

Foot2:

$$\begin{aligned}m_f \ddot{x}_8 &= -F_{x7} \\m_f \ddot{y}_8 &= -F_{y7} - m_f g \\I_f \ddot{\theta}_8 &= -F_{x7} l_{f1} \sin \theta_8 - F_{y7} l_{f1} \cos \theta_8 + T_{p7} + T_{a7}\end{aligned}$$