

# Humanoid hip workout

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Consider a humanoid robot in the following configuration:

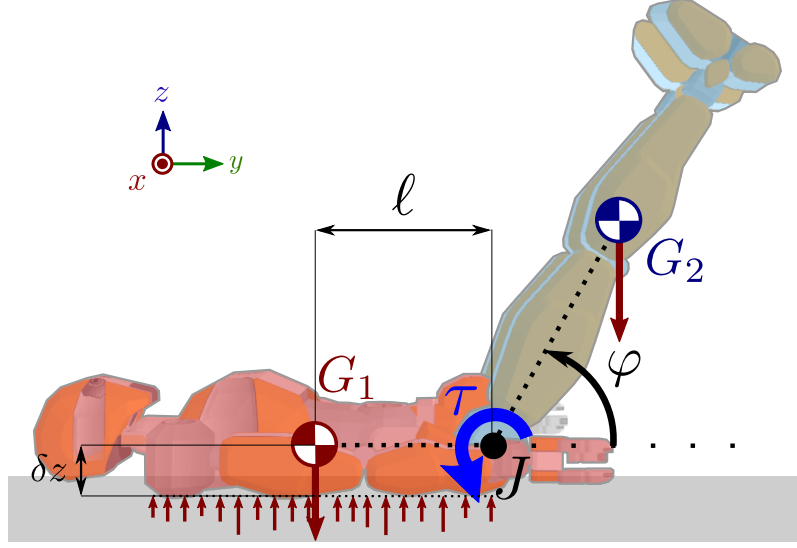


Figure 1: JVRC humanoid model lying on a horizontal floor.

We consider the problem in the sagittal plane. The robot is lying on a horizontal floor, holding a static posture where its hips are making an angle  $\varphi$  with the horizontal.

Let us denote by  $m_1$  and  $G_1$  the total mass and center of gravity of the robot's upper body (all links above the hips, red in Figure 1), and similarly  $m_2, G_2$  for the legs (blue in Figure 1).

- **Question 1:** What angle  $\varphi$  maximizes the hip torque  $\tau$ ?

We assume that all forces between the floor and the back of the robot are exerted over a horizontal surface located at an altitude  $\delta z$  below the center of gravity  $G_1$ .

- **Question 2:** What is the critical angle  $\varphi_{\text{tilt}}$  beyond which the robot cannot keep its back flat on the floor?