Humanoid hip workout

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Consider a humanoid robot in the following configuration:

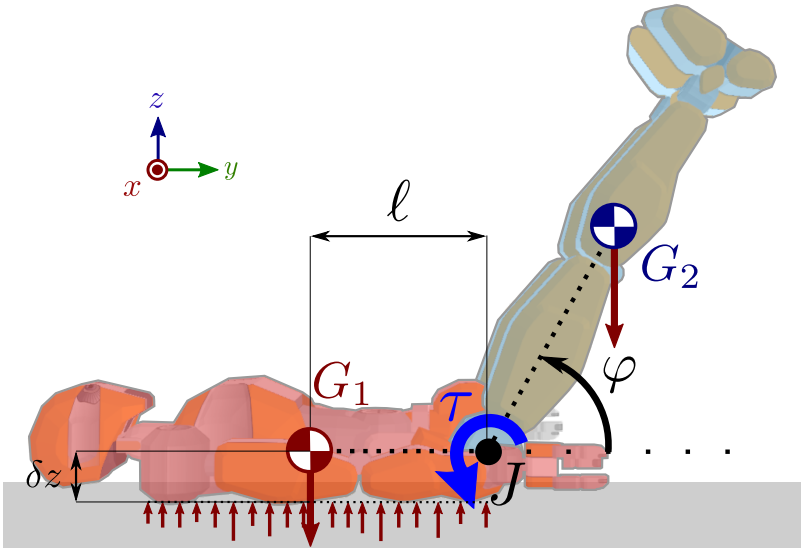

Figure 1: JVRC humanoid model lying on a horizontal floor.

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 φ 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 φ maximizes the hip torque τ?*

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

- **Question 2:** *What is the largest angle φ at which the robot can lift its legs while keeping its back flat on the floor?*

