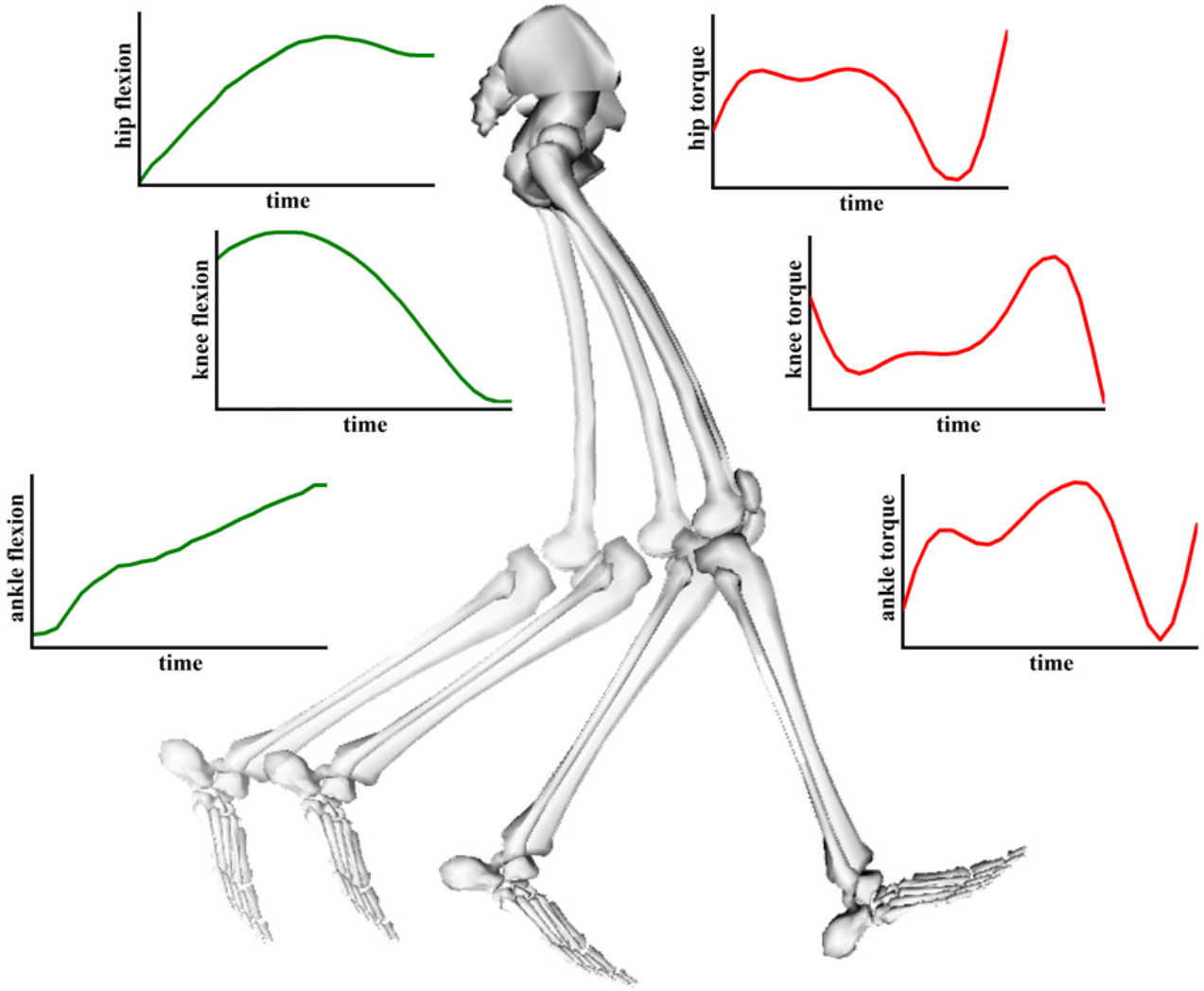



# Inverse Dynamics

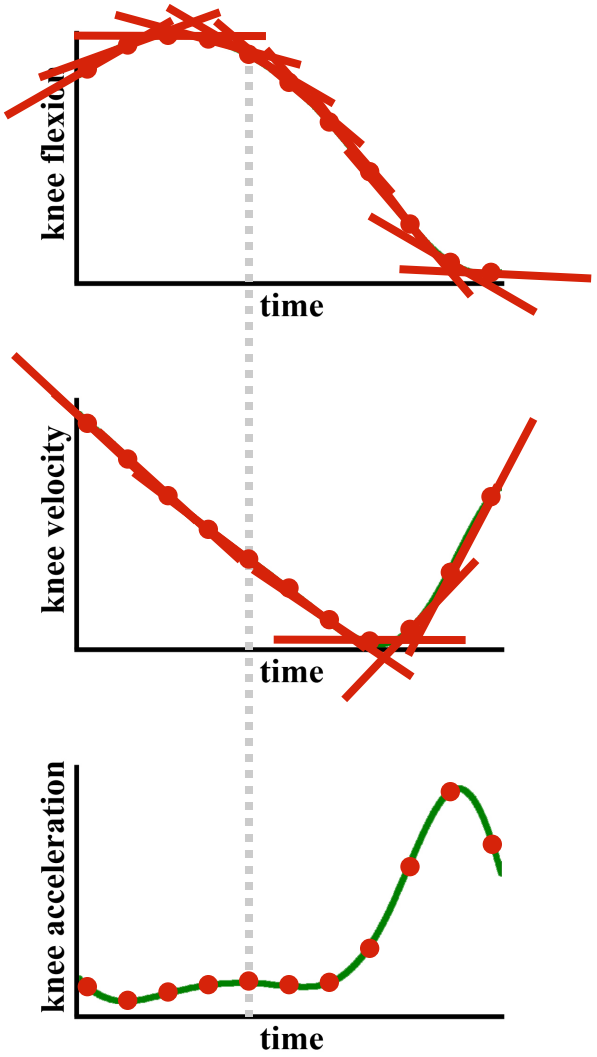
## OpenSim Workshop

# Key Concepts

- Kinematics: coordinates and their velocities and accelerations
- Kinetics: forces and torques
- Dynamics: equations of motion

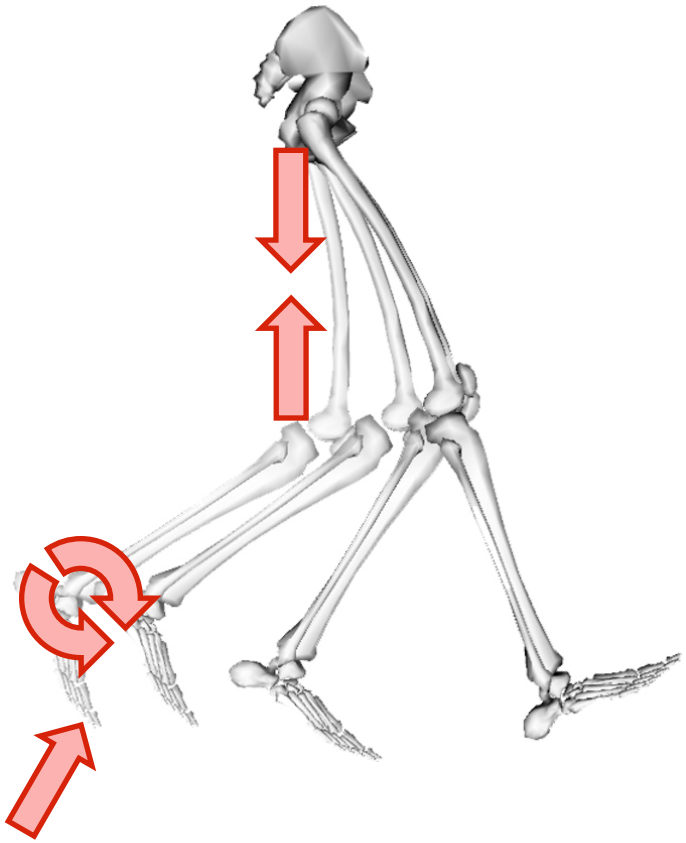
# Kinematics: Coordinates and their Velocities and Accelerations

- Coordinate
  - Joint angle or distance specifying relative orientation or location of two body segments
- Coordinate velocity
  - Derivative (rate of change) of a coordinate with respect to time
- Coordinate acceleration
  - Time derivative of a coordinate velocity with respect to time
- Kinematics
  - Set of all coordinates and their velocities and accelerations



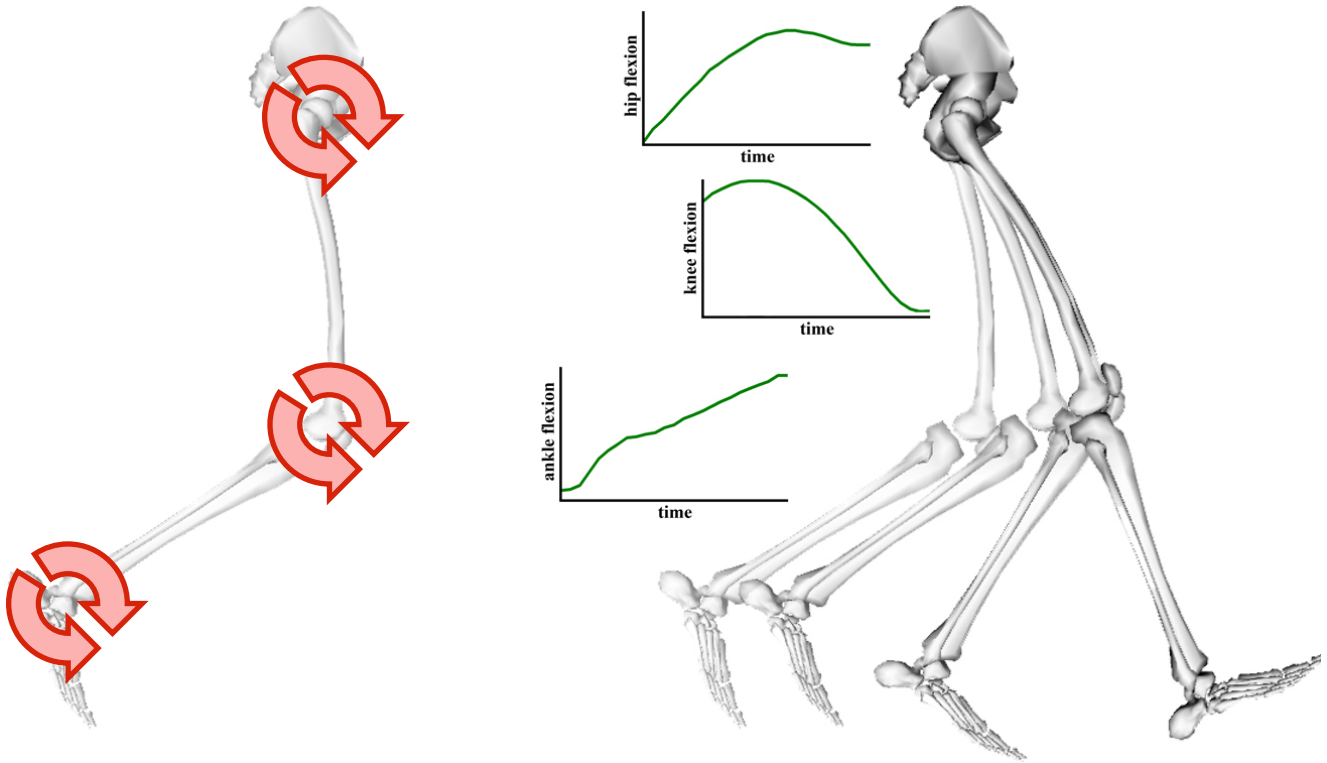
# Kinetics: Forces and Torques

- Kinetics
  - Forces and torques cause the model to accelerate
- Force
  - Applied to points (e.g., ground reactions) or between points (e.g., muscles)
- Torque
  - Applied to a coordinate (e.g., joint torque)



# Dynamics: Equations of Motion

$$\underbrace{\tau}_{\text{unknowns}} = \underbrace{M(q)\ddot{q} - C(q,\dot{q}) - G(q) - F}_{\text{knowns}}$$



# Exercise

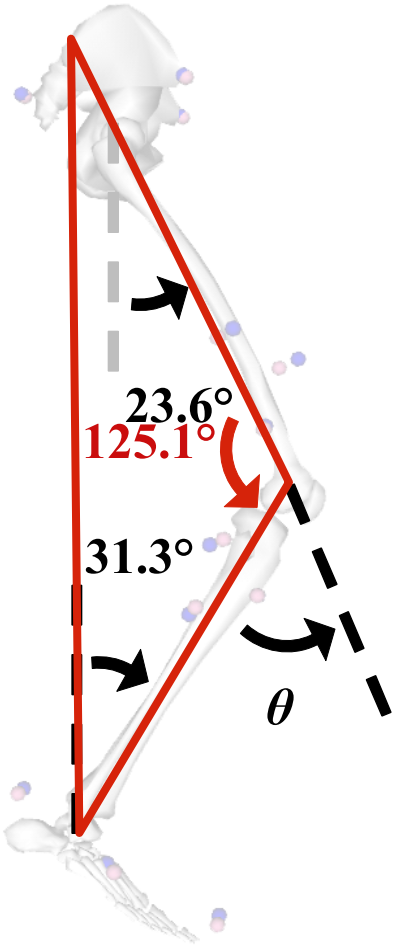
1. For the model shown on the right, what is the **value (*θ*)** of the **knee** coordinate (*Note:* **extension is +**)?

   A. 23.6°

   B. -54.9°

   C. 31.3°

   D. -125.1°



# Exercise

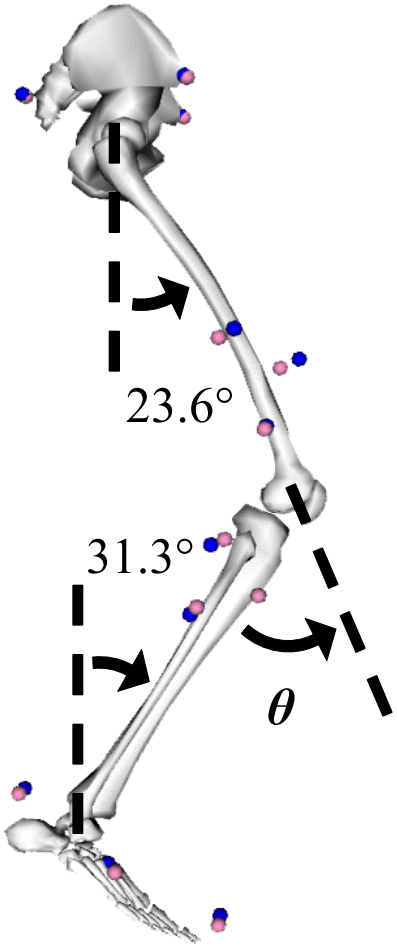
2. Given that the **model** shown on the right is ***at rest***, what is the **velocity** of the knee?

   A. 23.6°/s

   B. -54.9°/s

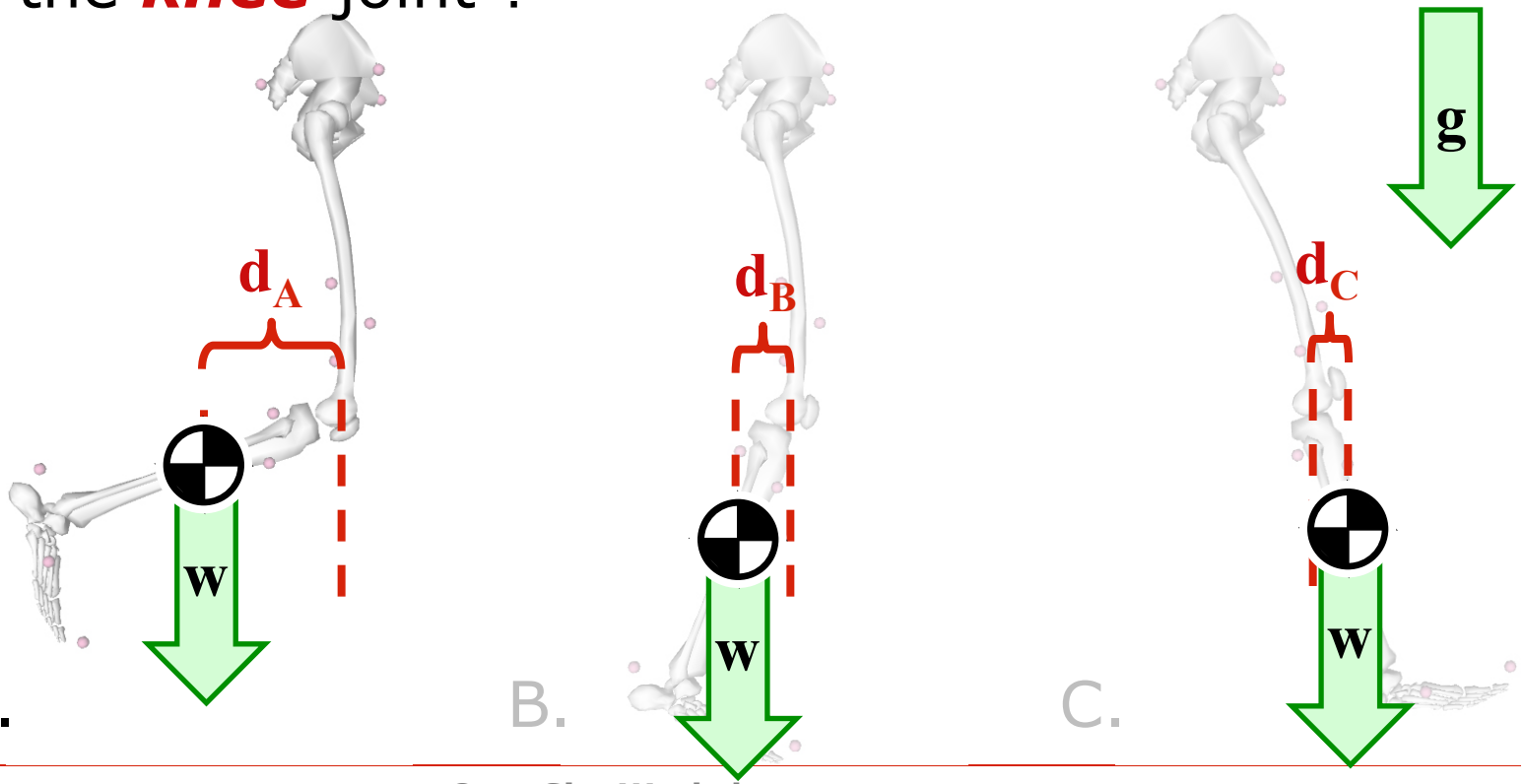
   C. 3.89°/s

   D. 0°/s



# Exercise

3. For the **model poses** shown below ***at rest*** and with **gravity (*g*)** as the ***only force*** acting on the model, **which pose** requires the ***largest*** **torque** at the ***knee*** joint ?



# Kinematics: Coordinates and their Velocities and Accelerations

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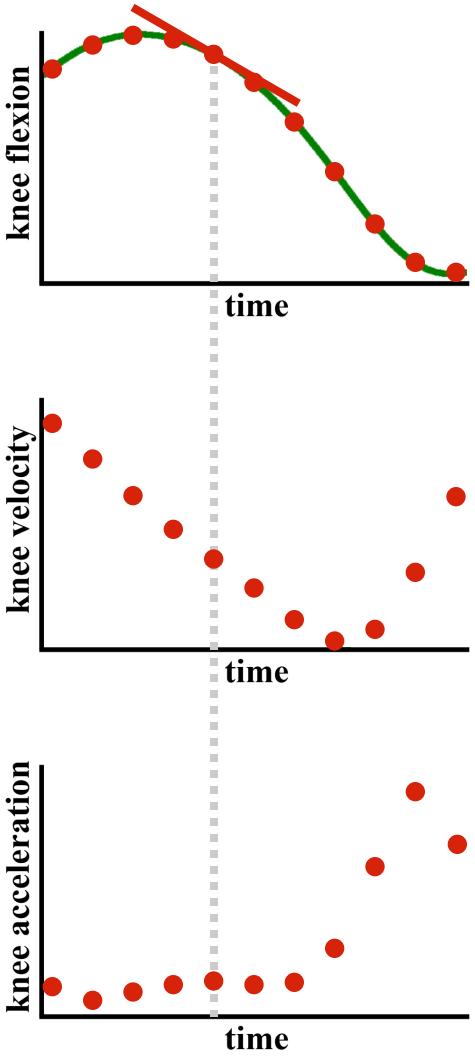

# Kinematics: Coordinates and their Velocities and Accelerations

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