# PLANAR SIMULATION OF HUMAN MOTION

## Segment Linear Momentum

$\underline{L}_i = m_i \, \underline{v}_i$

where:
$\underline{L}_i$ = segment linear momentum
$m_i$ = segment mass
$\underline{v}_i$ = linear velocity of the segment centre of gravity

## Segment (Local) Angular Momentum

$p_i = I_i \, \omega_i$ or $p_i = I_i \, (\omega_1 + \omega_{i/1})$

where:
$p_i$ = segment angular momentum
$I_i$ = segment moment of inertia
$\omega_{i/1}$ = segment angular velocity relative to the trunk angular velocity
$\omega_1$ = trunk angular velocity

## Segment (Remote) Moment of Momentum

$\underline{M}_i = \underline{r}_i \times m_i \, \underline{v}_i$
since $\underline{v}_i = \underline{v}_T + (\underline{r}_i \times \underline{\omega}_i)$
therefore $\underline{M}_i = \underline{r}_i \times m_i \, [\underline{v}_T + (\underline{r}_i \times \underline{\omega}_i)]$

where:
$\underline{M}_i$ = segment moment of momentum
$m_i$ = segment mass
$\underline{r}_i$ = vector joining the centre of gravity of the segment and the centre of gravity of the total body
$\underline{v}_i$ = first derivative of $\underline{r}_i$ (linear velocity of the segment centre of gravity)
$\underline{v}_T$ = total body linear velocity
$\underline{\omega}_i$ = segment angular velocity

## Total Body Angular Momentum

$$p_T = \sum_{i=1}^{11} M_i + \sum_{i=1}^{11} p_i$$

= constant (when resultant force is a central force, e.g., gravity)

where:
$p_T$ = total body angular momentum
$M_i$ = segment moment of momentum
$p_i$ = segment angular momentum

## Trunk Angular Momentum

$$p_1 = p_T - \sum_{i=1}^{n} M_i - \sum_{i=2}^{n} p_i$$

where:
$p_1$ = total body angular momentum of the trunk
$p_T$ = total body angular momentum
$M_i$ = segment moment of momentum
$p_i$ = segment angular momentum (excluding trunk)

## Angular Velocity of Trunk

$\omega_1 = p_1 / I_1$

where:
$\omega_1$ = trunk angular velocity
$p_1$ = trunk angular momentum
$I_1$ = total body moment of inertia

## Trunk Angle

$\theta_1(j) = \omega_1(j)\, t + \theta_1(j-1)$

where:
$\theta_1(j)$ = trunk angle at $j^{th}$ time interval
$\omega_1(j)$ = angular velocity of trunk
$t$ = time interval

## Input parameters

- Takeoff velocity (magnitude and angle)
- Orientation at takeoff (includes centre of gravity location)
- Segment lengths
- Total body mass
- Total body angular momentum at takeoff
- Time increment
- Changes in joint angles

## Output parameters

- Trajectory of centre of gravity
- Trunk angular positions
- Total body orientations (trajectories of all joints)