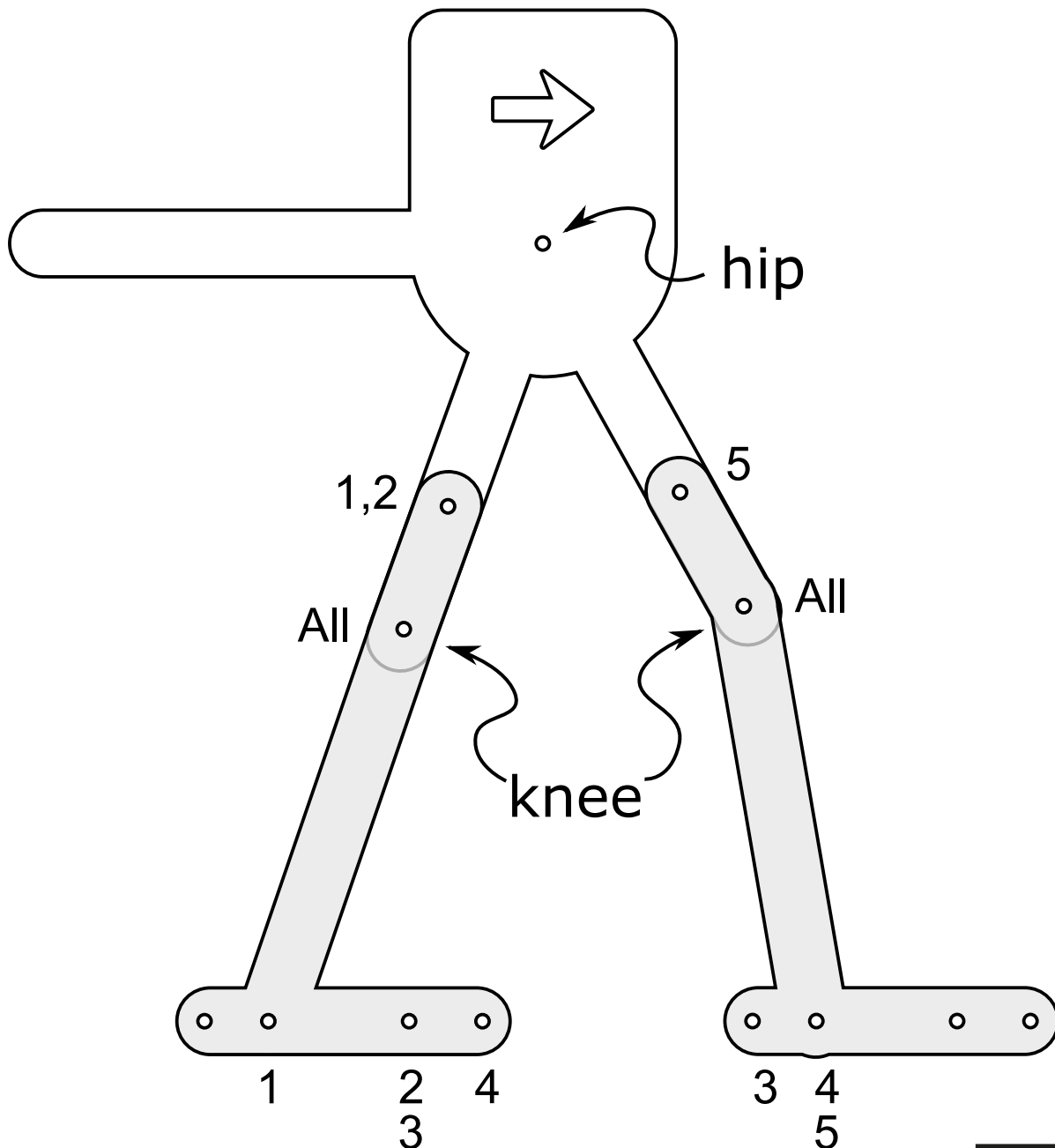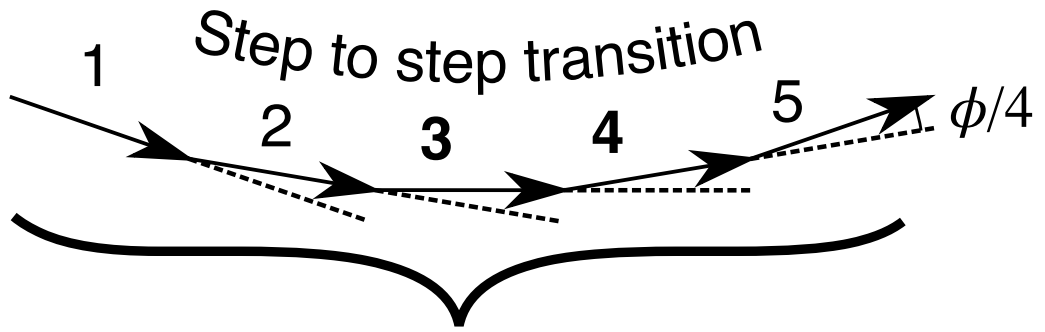**Overview**
In human walking, the body rises and falls over a stance leg before a smooth step-to-step transition into the next vaulting stance. The transition results from joints locking and unlocking in rapid sequence due to simple geometric changes loading and unloading a series of muscles. The geometry that makes the transition smoothest - and so mechanically most economical - predicts human leg and foot proportions: a knee half-way down the leg; short toes and heels; and a stiff, longer midfoot.

**Operating instructions**
A) Prepare the card by pushing a pin through each of the 8 foot holes below.
B) Connect the three MDF model parts at the knees with split pins.
C) For any 'snapshot' (1-5) connect two other split pins as indicated in diagram below. Foot pins go through the MDF parts and the card; the thigh connections go through two layers of MDF but not the card.
D) For each snapshot, trace and label the arcing path described by the hip with a pen through the 'hip' hole.
E) Note that the arcs intersect at the step-to-step transition with angles progressing from down to up.
F) Use the model configured at different snapshots to explore the geometry shown over the page, and note how the various linkages result in the evenly spaced sequence of 'virtual legs' (blue) over which the hip vaults. The even spacing of virtual legs results in the smoothest step-to-step transition, and predicts realistic leg and foot proportions.



hip

1,2

5

All

All

knee

1     2   4        3   4
      3            5

*Step to step transition*

1  2  **3**  **4**  5  $\phi/4$

Vaulting stance

4a 3a  4b 3b

$\phi$

$\phi$

1 2 3 4 5

$\phi/4$