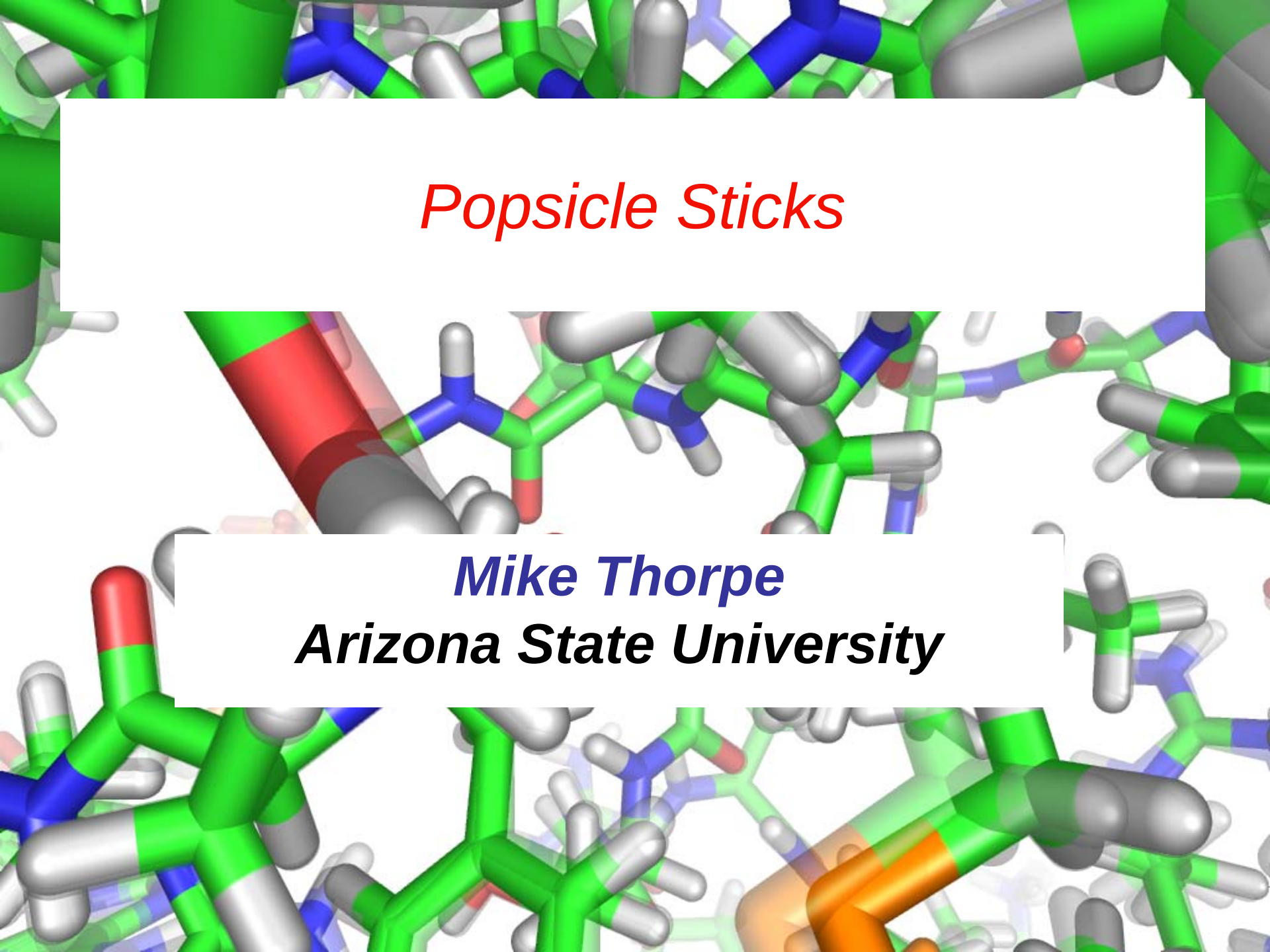

Popsicle Sticks

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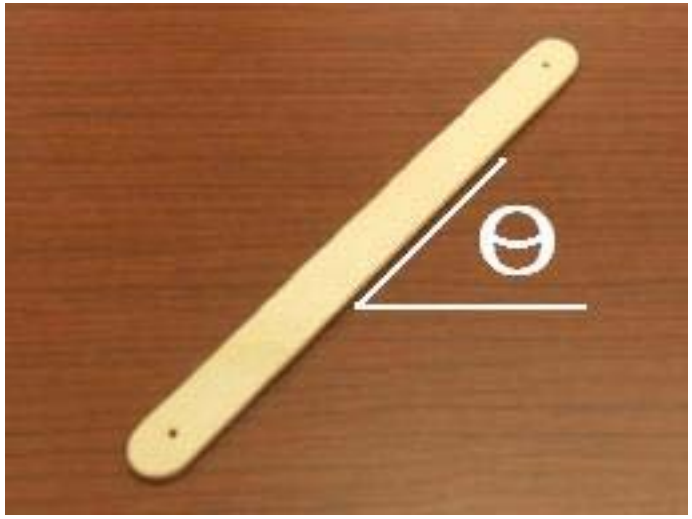
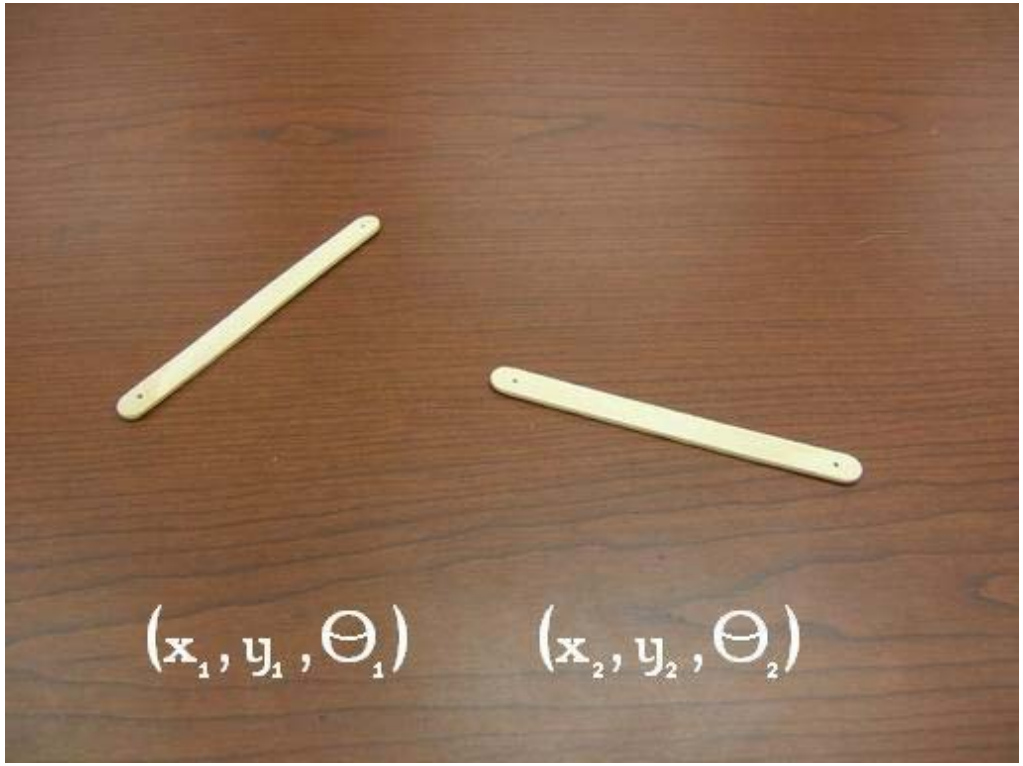
1 rigid stick

- How many degrees of freedom (dof) does a stick on a table have?
  - 2 translational (x, y)
  - 1 rotational (θ)
  - Total dof = 3
  - (x, y, θ) describes the position of the stick.



2 rigid sticks

- What about 2 sticks?



  - Stick 1: (x_1, y_1, θ_1)
  - Stick 2: (x_2, y_2, θ_2)

  - All 6 dof are independent.

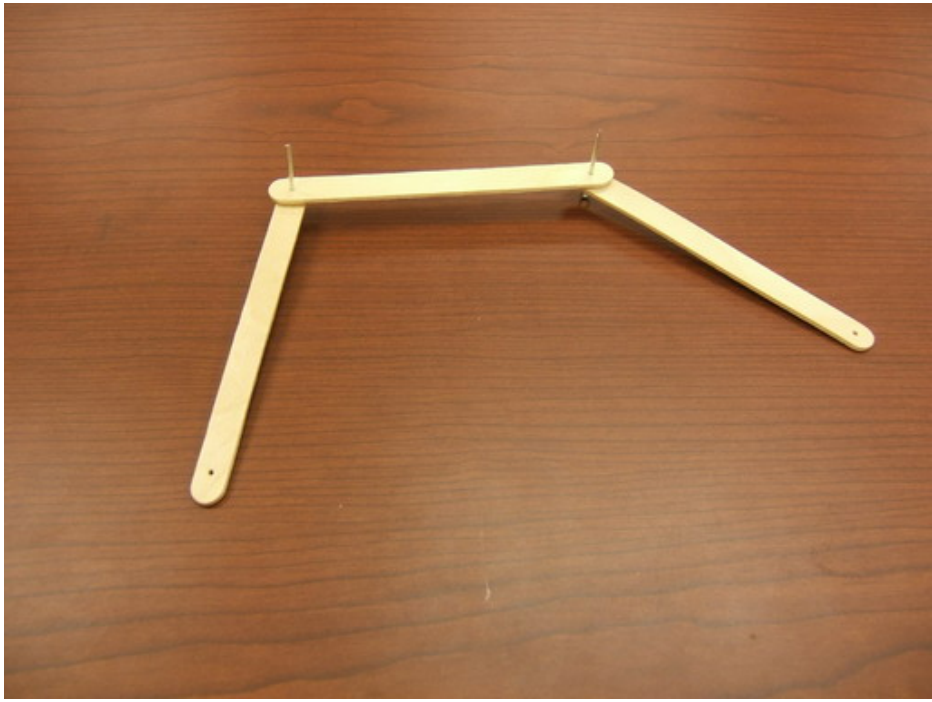
  - Total dof = 3 + 3 = 6

2 sticks and 1 connection

- What happens to dof?
  - Stick 1: (x_1, y_1, θ_1)
  - Stick 2: (x_2, y_2, θ_2)
  - Not all dof independent.
  - We require $x_1 = x_2$. and $y_1 = y_2$.
  - dof = 3 + 3 – 2 = 4
  - Interpretation: Rigid body (dof = 3) + Internal angle (dof = 1)

3 sticks and 2 connections

- What happens to dof?



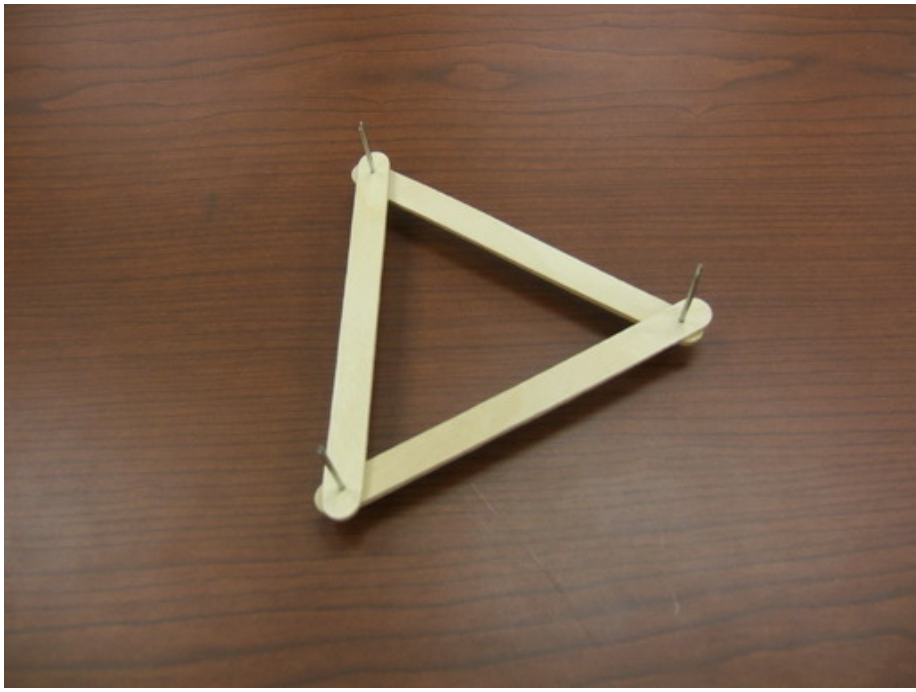
  - Stick 1: (x_1, y_1, θ_1)
  - Stick 2: (x_2, y_2, θ_2)
  - Stick 3: (x_3, y_3, θ_3)

  - dof = 3x3 – 2x2 = 5

  - Rigid body (dof = 3) + Internal angles (dof = 2)

3 sticks and 3 connections

- What happens to dof?
  - 3 sticks
  - 3 connections
  - dof = 3x3 – 3x2 = 3
  - Rigid body (dof = 3)



Redundant constraints

- Can I remove a stick without changing the rigidity?