Jumping Man

Purpose:

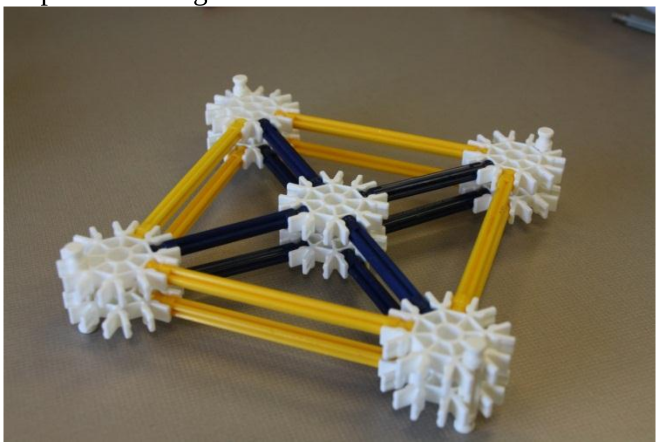
This activity looks at how to build a model to demonstrate the power transporting role of biarticular muscles. These are muscles that cross two or more joints. An example is the calf muscle which crosses the knee and ankle joints.

Materials:

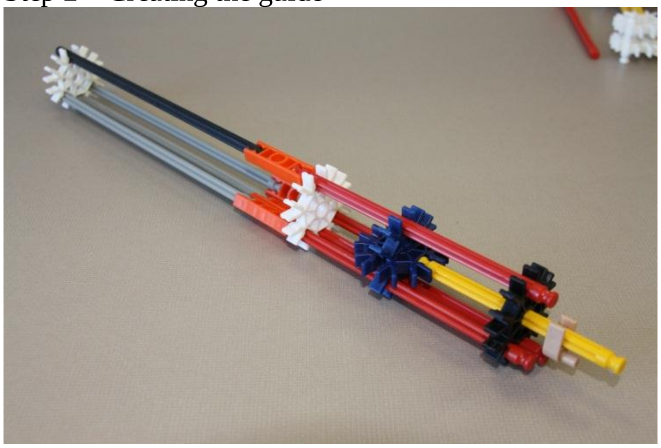
K'nex
Pipe cleaner
Rubber bands

Steps:

Step 1 – Creating the base



Step 2 – Creating the guide



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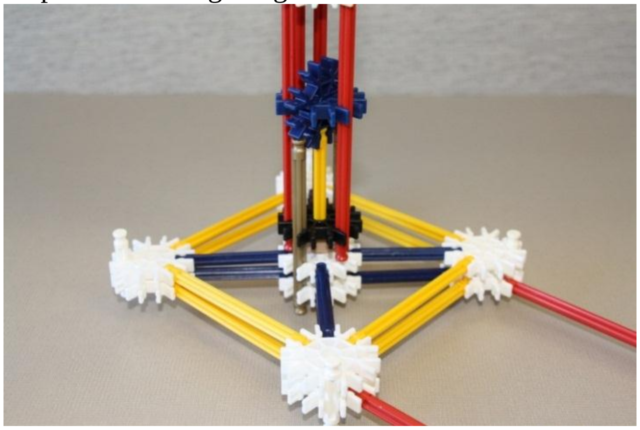
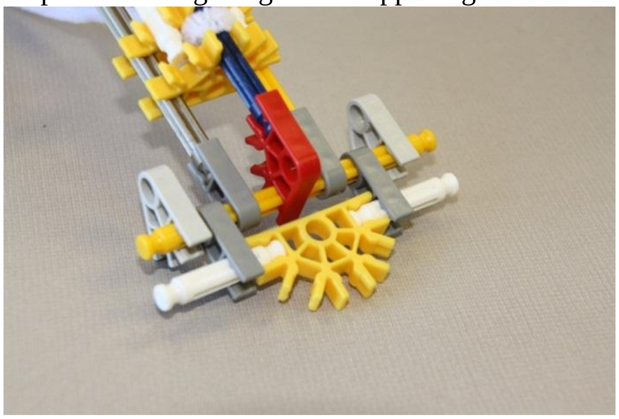
Step 3 – Attaching the guide to the base

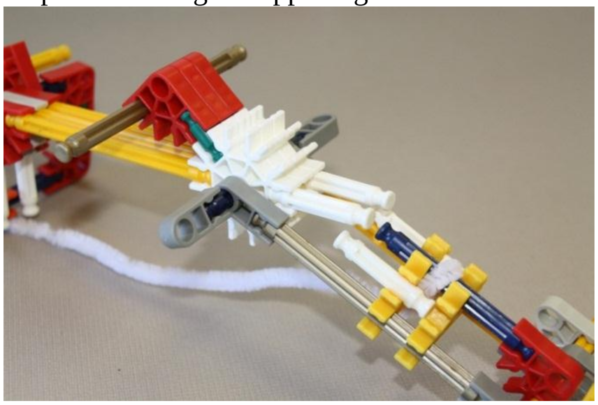


NOTE: The yellow rod on the guide protrudes through the circular openings on the white connectors in the center of the base. In-between the two white connectors is another peach color connector securing the lower end of the yellow rod within the guide. There are only 2 open connection points left on the two white connectors of the base and the black connector of the guide. Two gold rods are attached to these points to reinforce the connection.

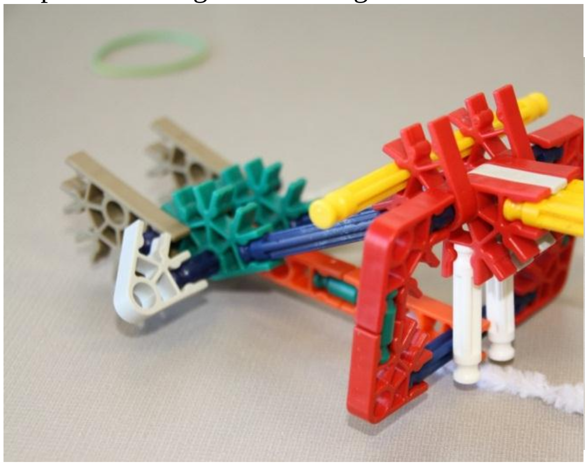
Step 4 – Creating the guide-to-upper leg attachment

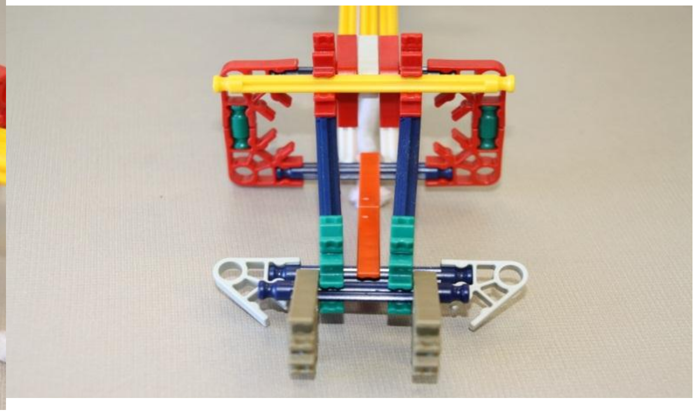


Step 5 – Creating the upper leg-to-knee connection

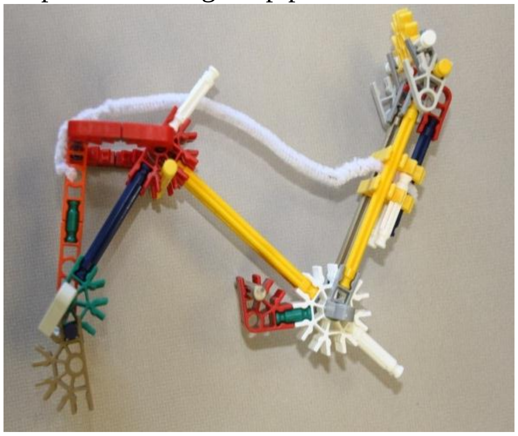


Step 6 – Creating the lower leg-to-foot connection and the foot

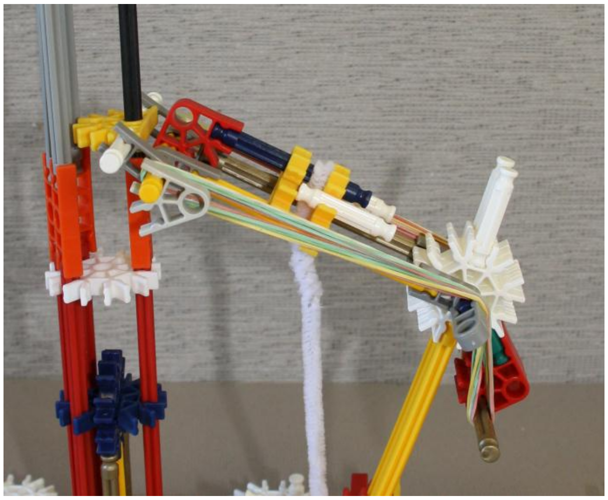




Step 7– Attaching the pipe cleaner

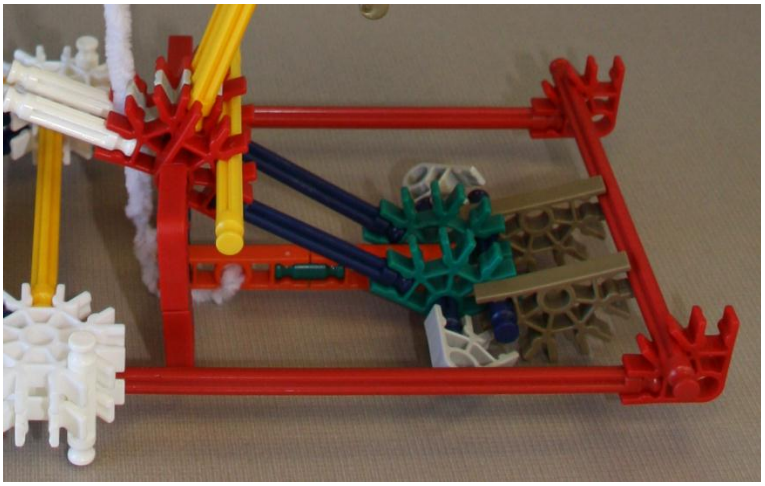


Step 8 – Attaching the leg to the guide and the rubber bands



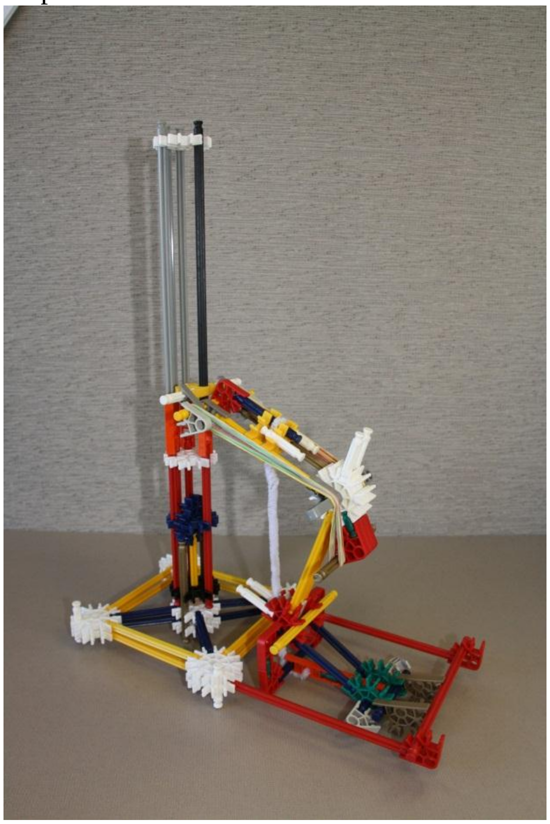
NOTE: The leg is attached to the guide rod through the center hole of the yellow connector. This allows the connection to slide up and down the guide rod. 5 to 7 rubber bands should be used for each side, but more can be inserted to power up the jump.

Step 9 – Creating and attaching the foot holster



NOTE: This part is only meant to keep the foot from slipping.

Step 10– Done!!



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A model to demonstrate the power transporting role of biarticular muscles

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In complex movements biarticular muscles may transport power generated by monoarticular muscles at one joint to another, more distal joint (Gregoire, Veeger, Huijing & van Ingen-Schenau, 1984; van Ingen-Schenau, Bobbert & Rozendal, 1987). This is demonstrated by an articulated model of a vertically jumping man in which the action of the monoarticular knee muscles (vastii) is simulated by a spring and the transporting role of the biarticular gastrocnemius by an inextensible wire (Fig. 1). The length of the wire can be adjusted so that it becomes taut and links 'origin' and 'insertion' at different stages in the jump.

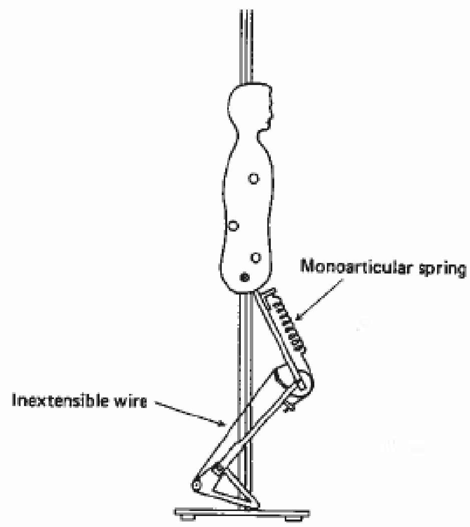

Fig. 1.

The height attained with the link in place is always greater than without, but the timing of the linking (determined by wire length) is critical for maximum effect: at optimum, the jump height is increased by 90 %. This is because, as the jump proceeds and the knee straightens, changes in the angular position of the knee have progressively less effect on vertical velocity of the model. By transporting energy from the monoarticular spring, which produces angular changes at the knee, distally to the ankle, a rapid flexion of the foot is produced: by this means the energy is more effectively translated into vertical velocity and greater height is attained in the jump. *In vivo* the situation is, not surprisingly, more complex, since the biarticular muscle may itself actively shorten, effectively adding to the power transported from the proximal to the distal joint.

REFERENCES

van Ingen-Schenau, G. J., Bobbert, M. F. & Rozendal, R. H. (1987). *J. Anat.* (In the Press).
Gregoire, L., Veeger, H. E., Huijing, P. A. & van Ingen-Schenau, G. J. (1984). *Int. J. Sports Med.* 5, 301–305.

Discussion Points:

1. Use elastic bands with weights hanging from them to demonstrate concepts such as (i) force, (ii) displacement (of the weight), (iii) gravity and (iv) graphing a dependent (displacement) versus independent (weight) variables.
2. Demonstrate muscles used during jumping exercises. How high can students jump? Is this height related to how tall they are?
3. Can students jump higher if they swing their arms? If so, why?
4. Discuss where springs are used in everyday items (garage door openers, pogo sticks, sling shots, elastic shoe laces etc).
5. For advanced students, talk about energy conversion, e.g., from elastic (spring) energy to kinetic energy.
6. For advanced students, discuss the mechanical design (involving springs) found in the neck of giraffes or in horse legs.