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2. Place the chair side ways to the wall. Have a student stand so that their feet are not under the chair, bend over at the waist and place their head against the wall so that their back is flat. Have them lift the chair and then stand up. Have both boys and girls try this. **Be ready to catch the boys!** *Explanation: The center of mass for boys is higher than for girls. When a boy is bent over, his center of mass is over the chair and he is balanced against the wall. When he tries to stand, he falls. A girl's center of mass is closer to her hips. Even when she is bent over, her center of mass is over her feet, and she can still stand.*
  3. One student will stand with their back against the wall. Place the quarter on the floor at their feet and tell them to pick it up. Most will not be able to do it. Occasionally a girl with extremely long feet will be able to do this. *When people bend over, their derriere extends to balance them, which keeps the center of mass over their feet. Against the wall an individual's derriere cannot counter balance them.*
  4. One student will stand with their side against the wall, arm and leg touching the wall with nothing to hold onto. Tell them to lift the other leg straight out away from the wall. *The explanation is the same as for number three. This time their upper body can not move to balance them.*
  5. One student will put on their backpack and perform any of the above demonstrations. What happens? *The additional weight changes their center of mass. Discuss why girls should wear their backpacks lower and in the front, where boys should wear their packs higher and on their backs. Answer: The closer an individual can get the mass near their natural center of mass; the easier it is for their body to handle the additional mass.*

### **Extensions:**

- Find a mathematic equation for finding the center of mass.
  - Find the center of mass of a custom built vehicle at:  
<http://www.worldforchrist.org/races/common/cmplace.htm>
  - Find the center of mass of a foam block. Mark the center of mass with a blue spot. Mark the edge with a red spot. Grab the block by one edge, with the marked side facing the class. Stand in front of but to one side of the lecture hall table. Toss the block up at a 35-55 degree angle so that it lands somewhere on the other side of the table, traveling in a plane perpendicular to the class. Make sure the block rotates, but not too fast. The idea is that the class can see the red spot move in circles about the blue spot, and that the blue spot moves in a parabola. You may repeat a few times.
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**References / Resources**

<http://hyperphysics.phy-astr.gsu.edu/hbase/cm.html>

[http://www.msms.doe.k12.ms.us/ap\\_physics/tutorials/chap5/chap5\\_4.html](http://www.msms.doe.k12.ms.us/ap_physics/tutorials/chap5/chap5_4.html)