Angular momentum

Phys H308, Haverford College

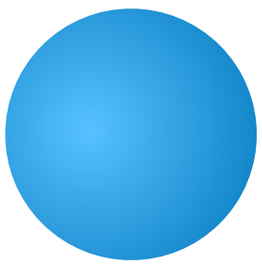
Ted Brzinski, Sept. 9 2022

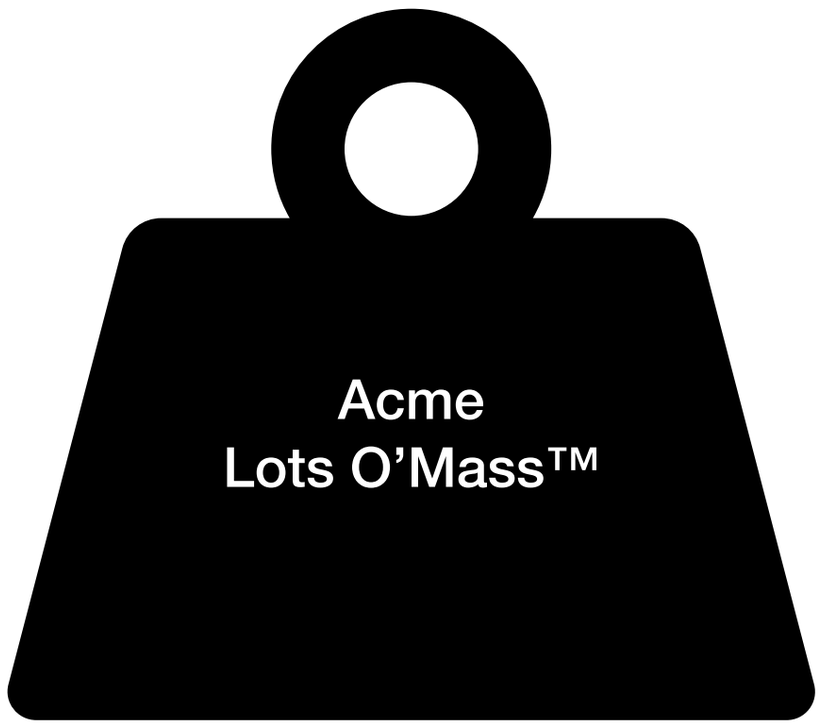
Recall: linear momentum

- Momentum: $\vec{p} = m\dot{\vec{x}}$
- Momentum is a conserved quantity:

  To change the momentum of a system, an external force must be applied: $\vec{F} = \dot{\vec{p}}$

Without external forcing, momentum is constant.





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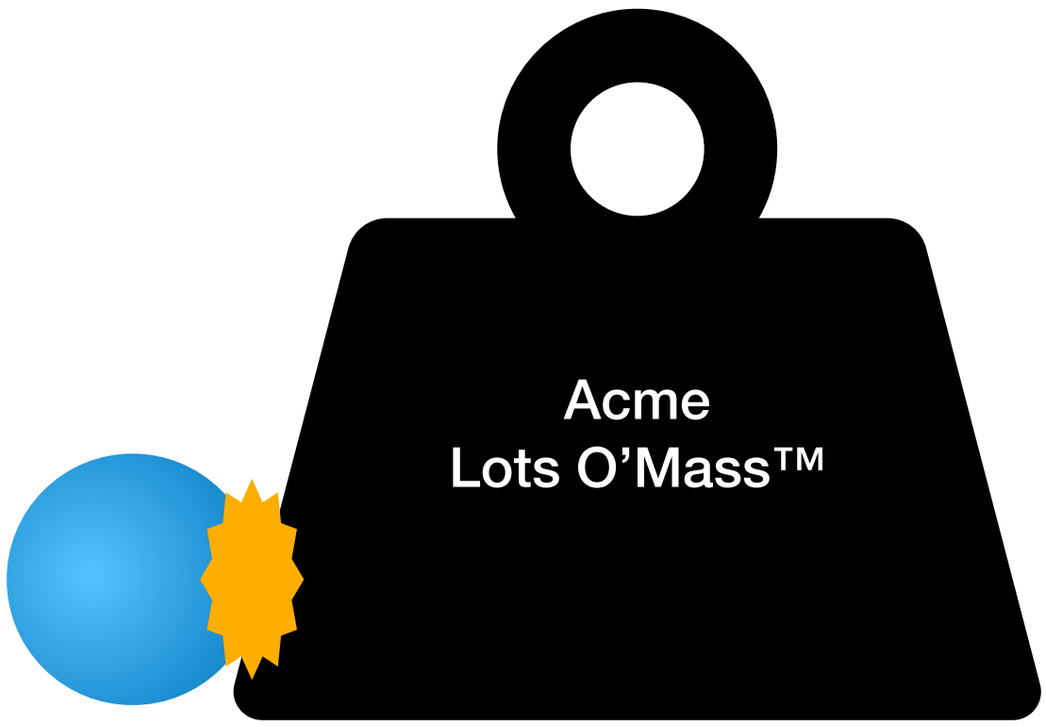

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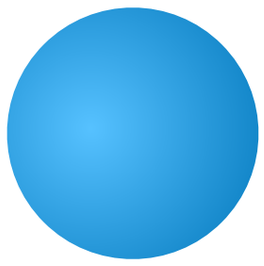
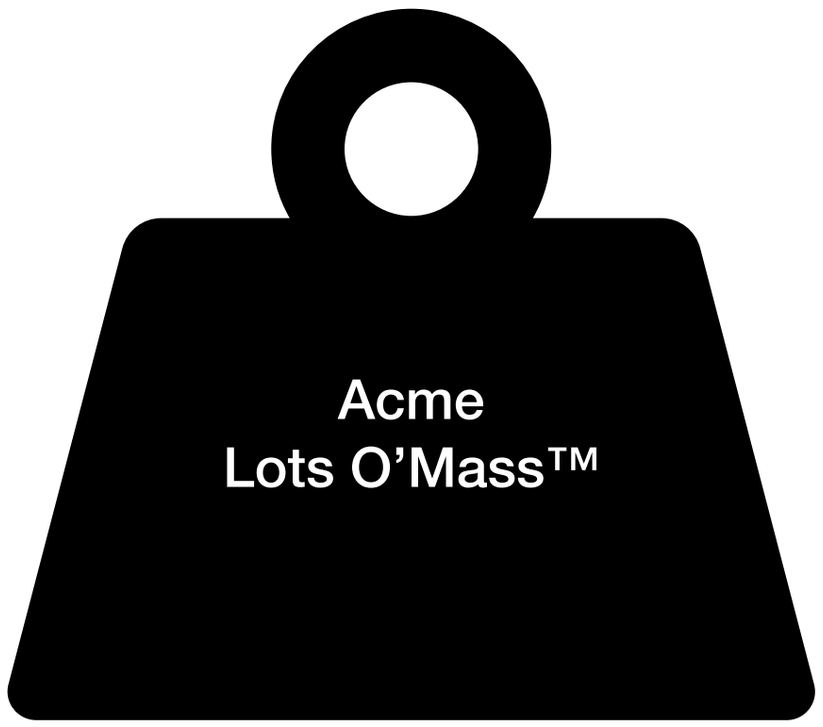
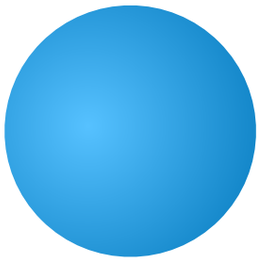
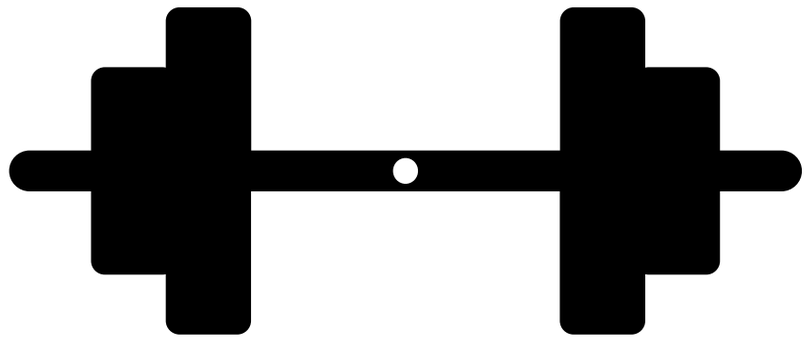




Angular momentum

- Momentum can also be stored in internal degrees of freedom (i.e. rotation)





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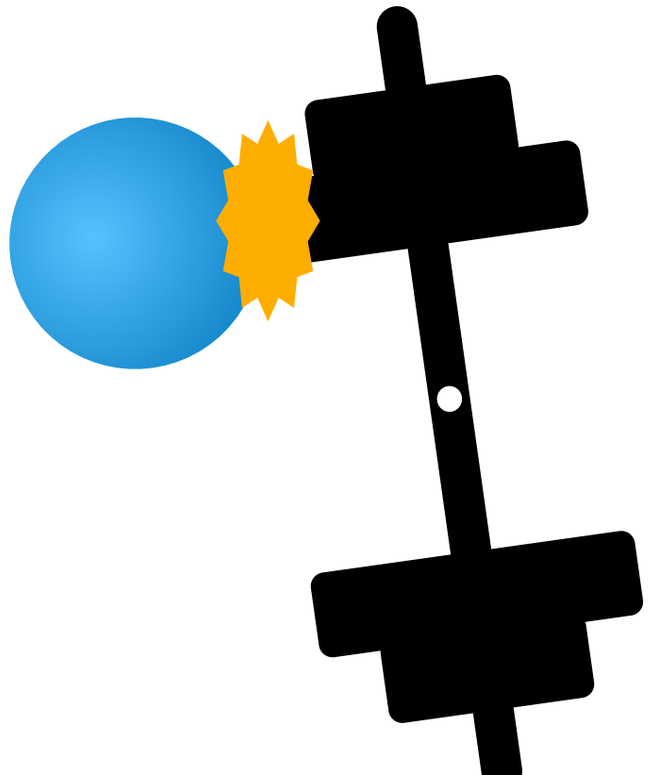

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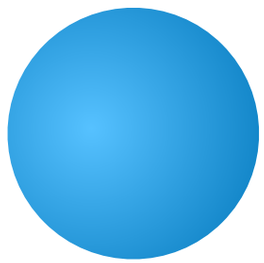

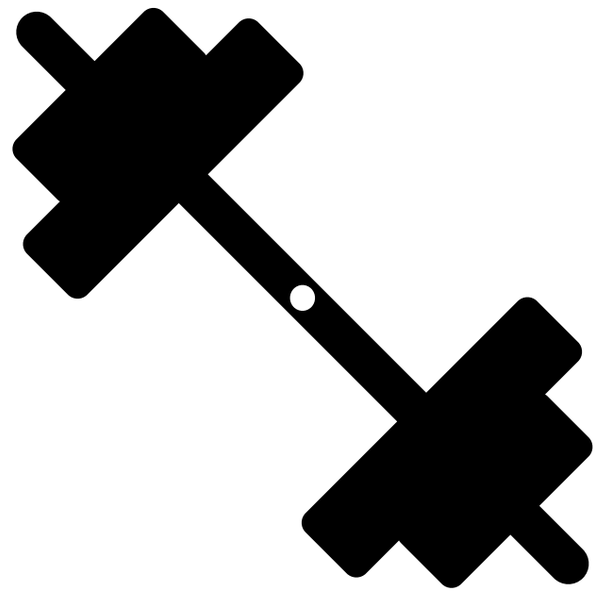

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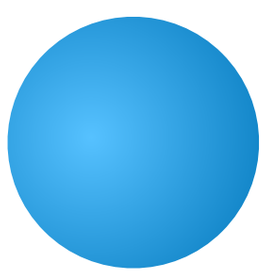
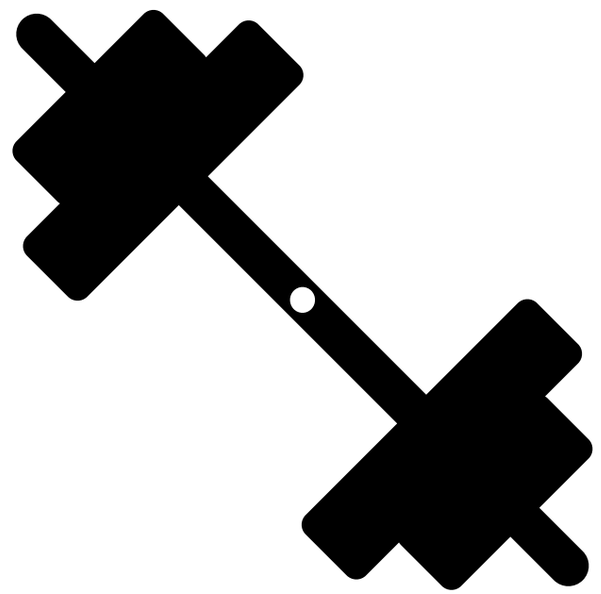
- Angular momentum:
  $\vec{\ell} = \vec{r} \times \vec{p}$ or $\vec{L} = I\vec{\omega}$

- An external torque is required to change the angular momentum:
  $\vec{\tau} = \dot{\vec{L}}$

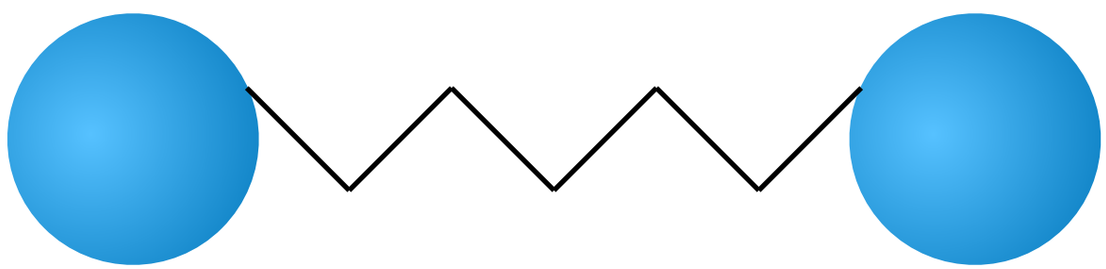




Angular momentum

Rotation is weird!

- Consider a pair of balls connected by a spring, and floating in empty space.



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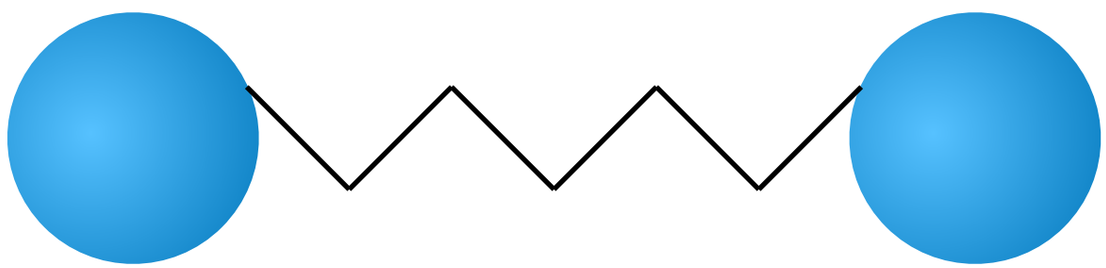
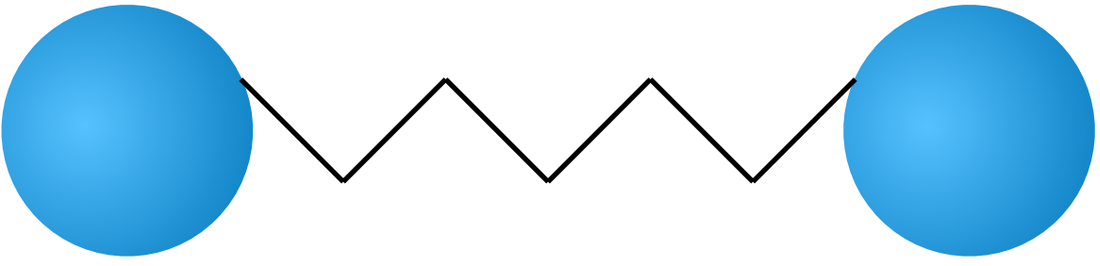


- Depending on my choice of reference frame, the springy barbell can have any linear momentum!



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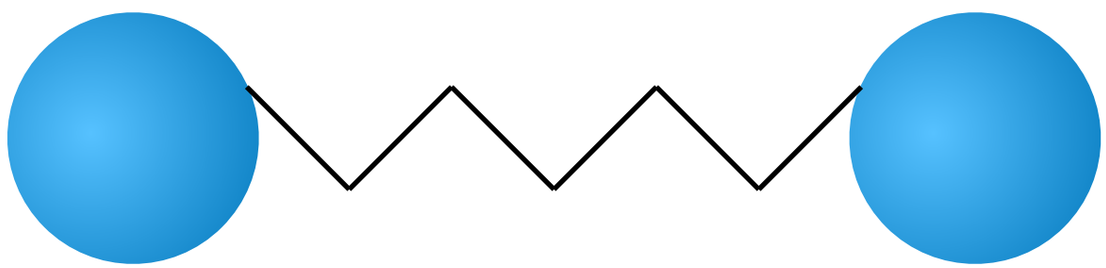

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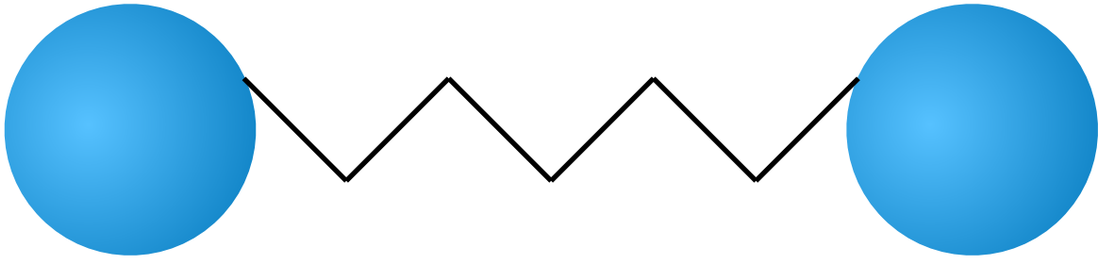

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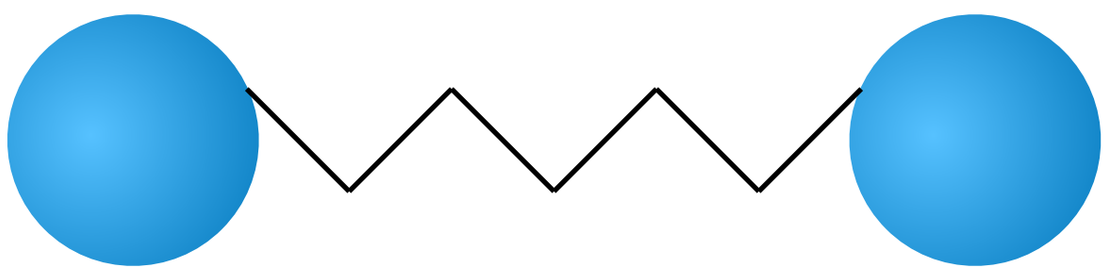

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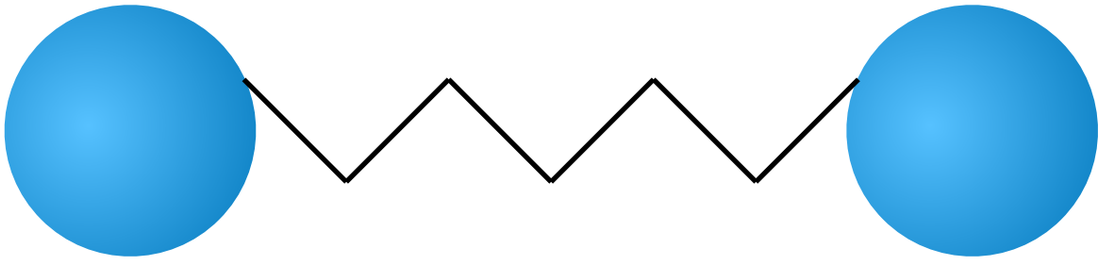
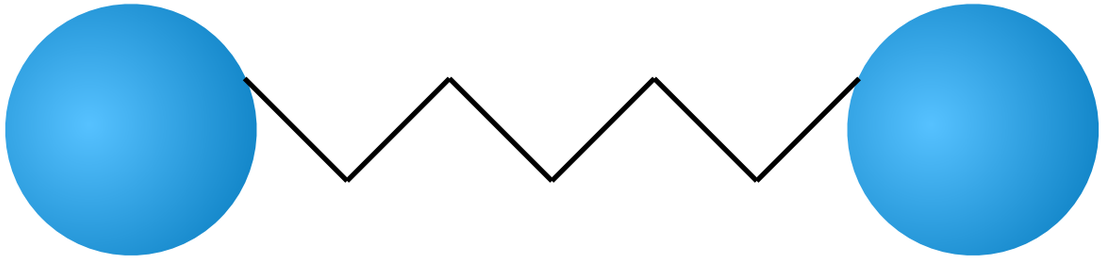


- That’s not true of the angular momentum, which can be read out of the extension of the spring!



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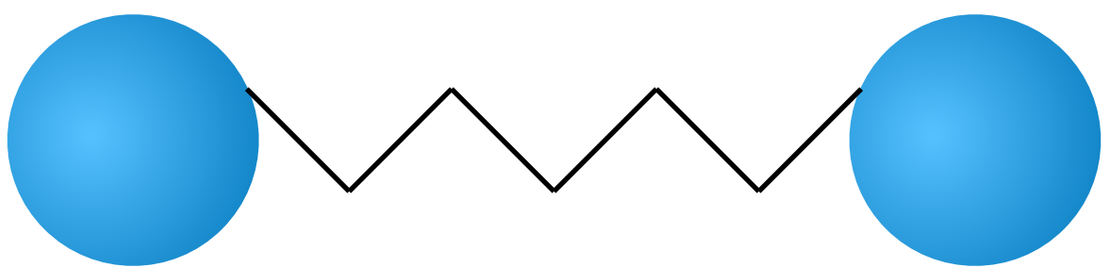

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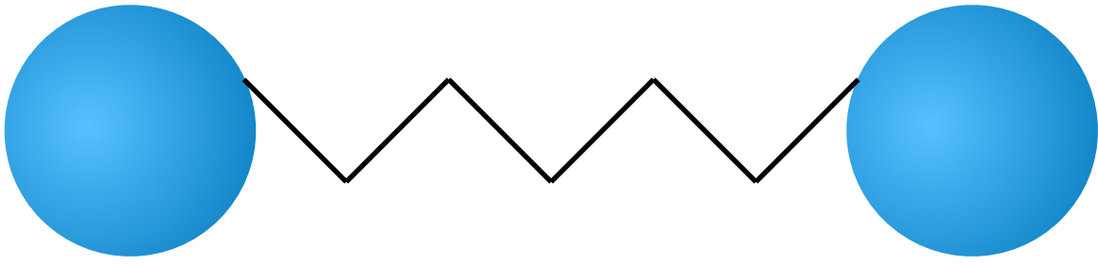

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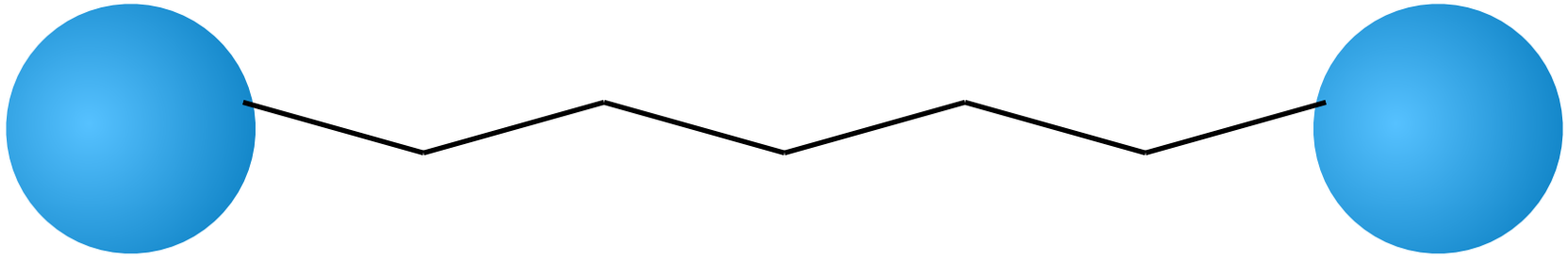
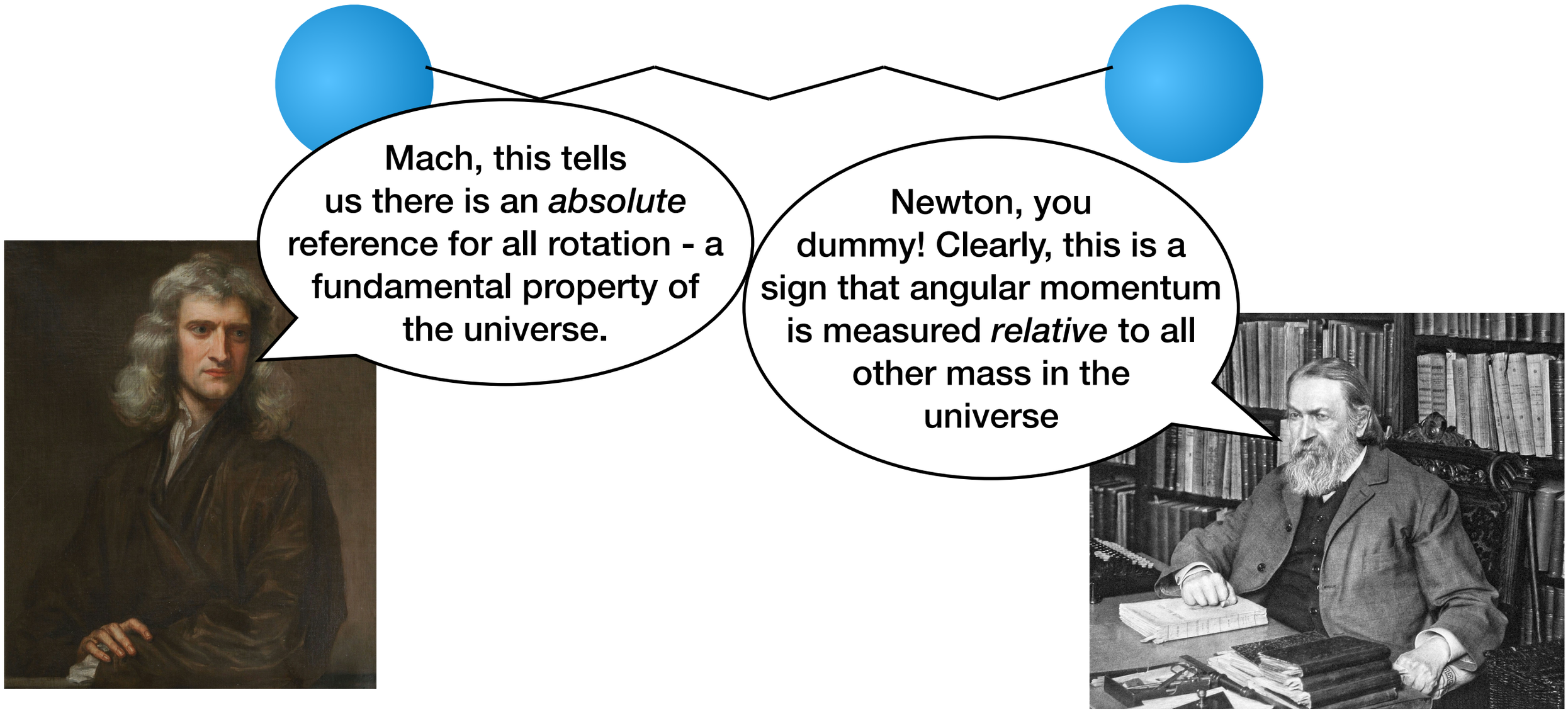


Why is rotation weird?

- Angular momentum, which can be read out of the extension of the spring, is measurable in any frame!



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