Learning Integration in Physics Using Debate Problems and Multimodal Communication

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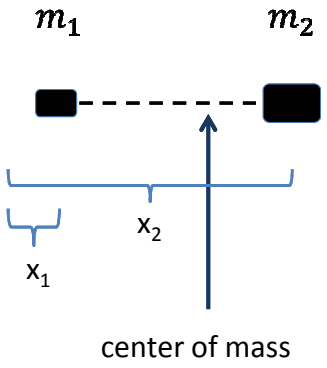
Integration example: center of mass formulas

- Discrete
- Continuous

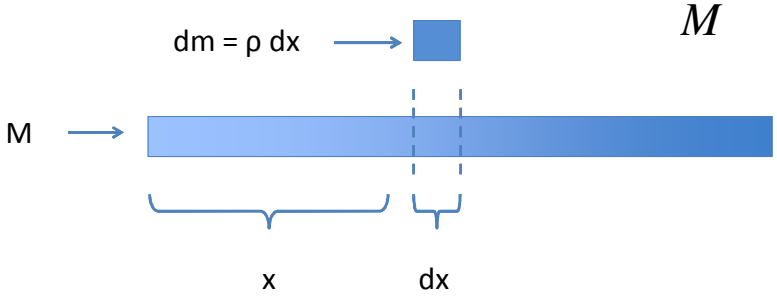
Discrete formula for center of mass



$$\frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

Continuous formula for center of mass

$$\frac{\int \rho\, x\, dx}{M}$$



"The discrete center of mass is: $\frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$
What is the integral expression?"

a) $\frac{\int m\,dx}{M}$ b) $\frac{\int \rho\,dx}{M}$ c) $\boxed{\frac{\int \rho\, x\,dx}{M}}$

How could a student demonstrate that he or she knows *why* this is the right answer?

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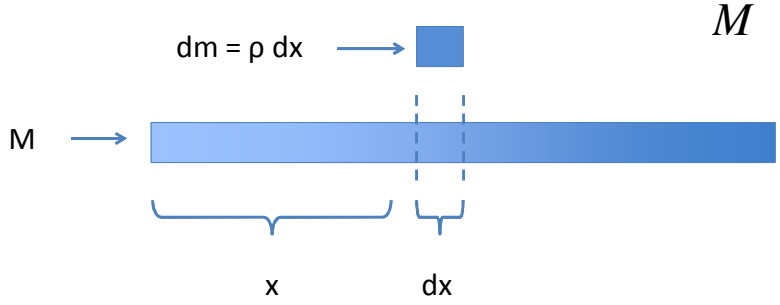
Representation of dx, x, dm, and M

$$\frac{\int \rho\, x\,dx}{M}$$



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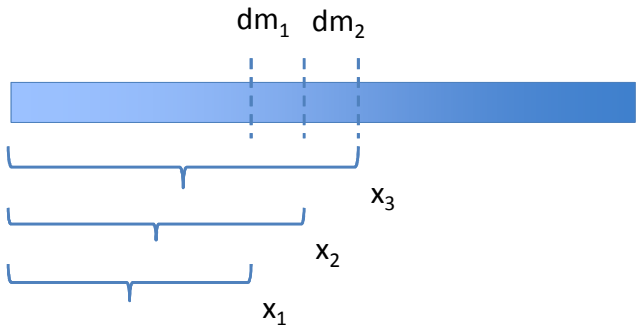
… as well as the *structure* of the summation: chopping and adding



and teach

How would you assess students' understanding of this integral?

1. Teach them the discrete formula, and ask them to derive the integral formula.
2. Teach them the integral formula, and ask them to apply it to a particular physical situation.
3. Ask them to talk about the structure of the integral, using multiple representations.

Lesson structure

- Participants: 16 students in an introductory mechanics class
- Six lessons, 1.5 hours each, over the course of 8 weeks.
- Students did not receive course credit, but were compensated financially.
- Students worked in groups of three or four. Eight students met on Tuesdays, and the other eight on Wednesdays.

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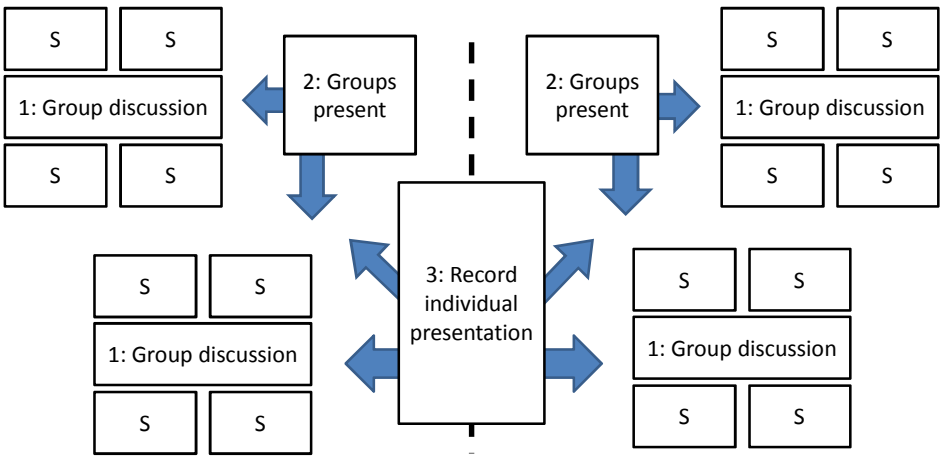
Communication Map



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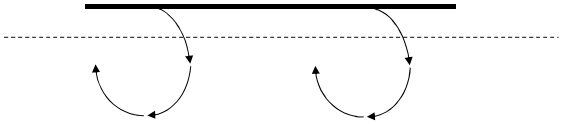
Individual presentations

- "Smartpen" records both writing and speech (audio).
- Similar to asking an essay question, only with audio.
- Spoken component gives students more ways to express themselves.

Debate problem



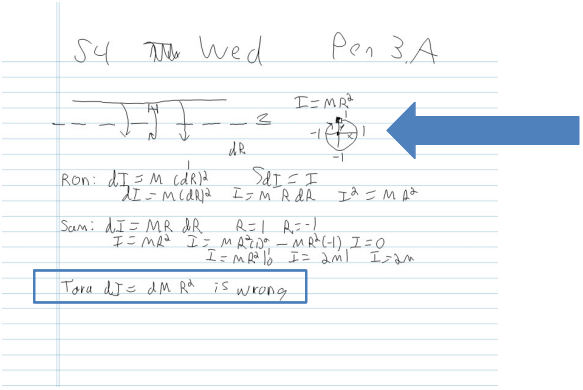
A rod is moving in a circle, around an axis parallel to itself, as shown in the picture. You have learned that moment of inertia is $I = M R^2$. Who is correct about the *infinitesimal* equation, and why?

Ron: The infinitesimal equation is $dI = M (dR)^2$

Sam: The infinitesimal equation is $dI = M R dR$

Tara: The infinitesimal equation is $dI = dM R^2$

Sample student work



Does "d" indicate change?

"We can conclude that, out of these, the thing that is changing is the radius […] since the **mass isn't changing, and R is,** that means Tara is wrong."

Students' first exposure to a static, spatial integral.

Conclusion

Presentations about debate problems are a valuable tool for instruction and assessment.

Students' experience with kinematics integrals can interfere with their ability to set up static integrals, since "d" refers to a *change* in the first case, and an *amount* in the second.

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