Learning Statics by Feeling:

Effects of Everyday Examples on Confidence and Identity Development

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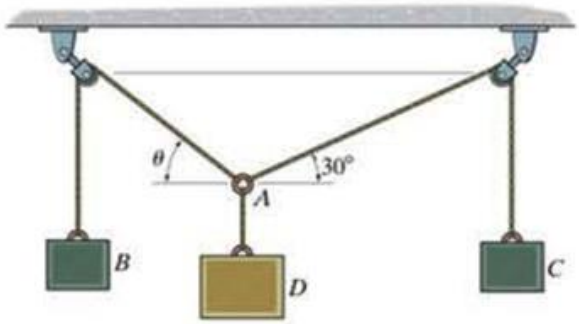
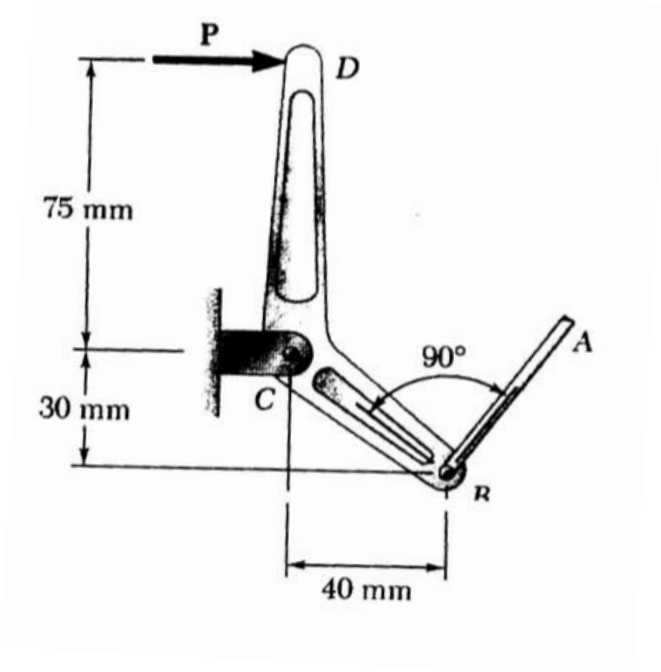
Why Engineering Statics?

- Sophomore Gateway
- “Valley of Despair”
- Abstract, not connected to real-world
- Increasingly large class sizes
- Impact Student Affect
  - Belonging
  - Identification with engineering





Previous Work

1) Concept Assessment Tool For Statics
   - Concept Inventory – evaluate classroom interventions
   - 10-yr development period and history of measuring outgoing student conceptual knowledge

2) Professional Role Confidence (Cech 2011)
   - Expertise Confidence: belief that one has sufficient knowledge to do the job of engineering
   - Career-Fit Confidence: does one want to do engineering, if the future job matches one's interests and values

3) Benefits of Active Learning
   - Collaborative, Cooperative, Problem-Based

E. Cech, B. Rubineau, S. Silbey, and C. Seron, "Professional Role Confidence and Gendered Persistence in Engineering," *American Sociological Review*, vol. 76, no. 5, pp. 641–666, Oct. 2011.

Engaging Students in Engineering

- **Everyday Examples in Engineering**

- **Title:** Sausages/Two-Dimensional Stress Systems
- **Subject Area:** Mechanics of Solids
- **Concept:** Mohr's Circle
- **Format:** 5 E's
  - Engage, Explore, Explain, Elaborate, Evaluate

Engage, "What is ENGAGE: Engaging Students in Engineering?," *Engageengineering.org*, 2012. [Online]. Available: http://engageengineering.org/

Patterson, et al. The effect of context on student engagement in engineering. European Journal of Engineering Education, 36(3):211–224, June 2011.

Research Questions

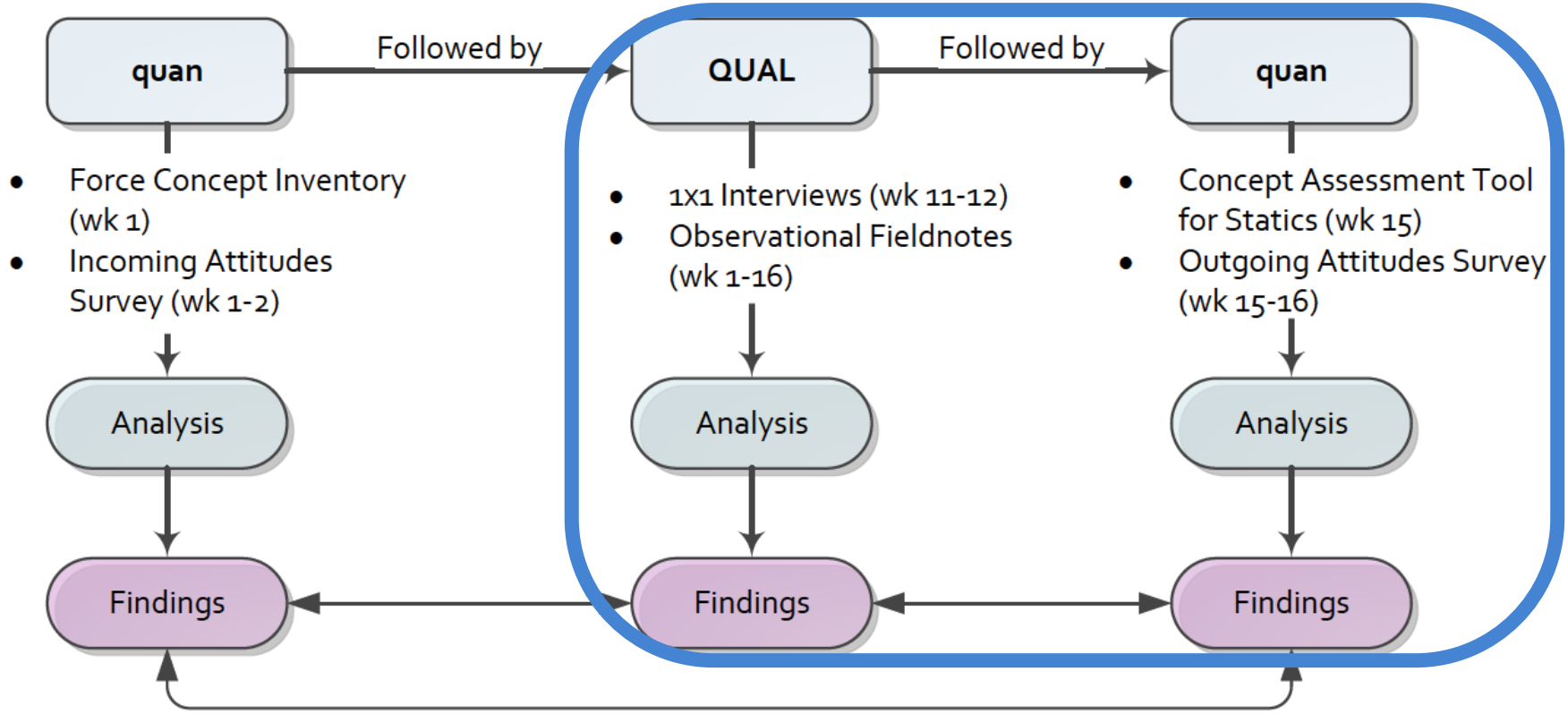
How does the *type* of everyday example affect student learning and attitudes?

1. Does the use of body-based vs. traditional examples affect student conceptual knowledge?

2. Does the use of body-based vs. traditional examples affect student confidence?

Assessment and Research Method

Sequential Explanatory Mixed-Methods Design



S. N. Hesse-Biber, *Mixed methods research: merging theory with practice*. New York: Guilford Press, 2010.

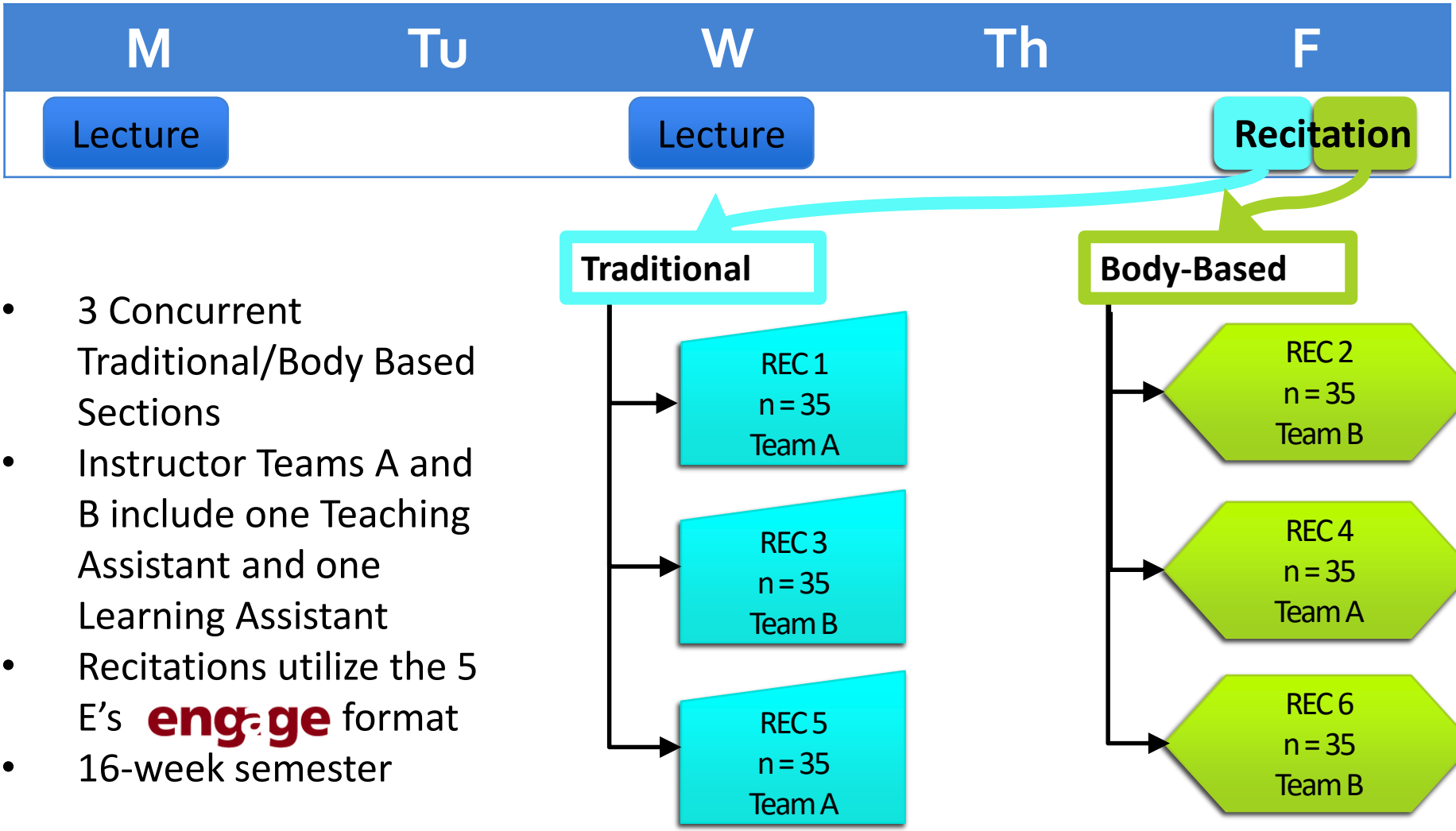
Quantitative Survey Instruments

- Concept Assessment Tool for Statics (CATS) on cihub.org
- Confidence in Solving Open-Ended Problems from (APPLES)
- Confidence in Math/Science Skills from (APPLES)
- Professional Role Confidence
  - Expertise Confidence
  - Career-Fit Confidence

S. Sheppard et al, "Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (CAEE-TR-10-01)," Center for the Advancement for Engineering Education, Seattle, WA, CAEE-TR-10-01, 2010.

E. Cech, B. Rubineau, S. Silbey, and C. Seron, "Professional Role Confidence and Gendered Persistence in Engineering," *American Sociological Review*, vol. 76, no. 5, pp. 641–666, Oct. 2011.

Course Structure/Format



- 3 Concurrent Traditional/Body Based Sections
- Instructor Teams A and B include one Teaching Assistant and one Learning Assistant
- Recitations utilize the 5 E's engage format
- 16-week semester

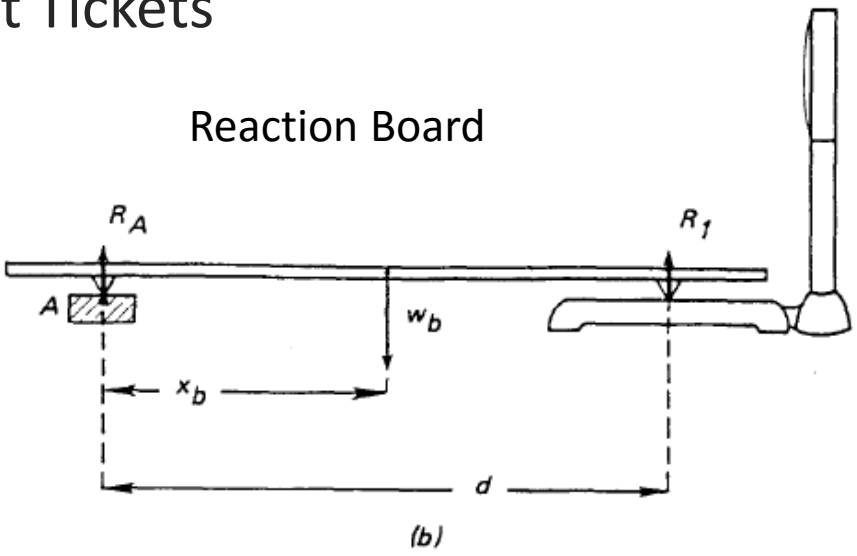
Detailed Lesson Example

- Week 11: Distributed Loading

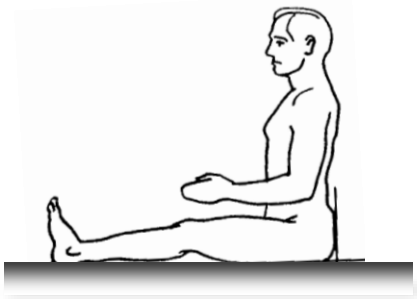
1. Engage – Demonstrate Reaction Board
2. Explore – Draw Relative Distributed Loading
3. Explain – Review Equations, Take Measurements
4. Elaborate – Make Predictions, and Solve
5. Evaluate – Exit Tickets

Traditional

Reaction Board



Body-Based



Preliminary Findings: CATS

Table 1: Concept Assessment Tool for Statics: Body-Based vs. Traditional

Body-Based		Traditional		$(\mu_T - \mu_B)$	P(T<=t) Two-tailed*
Mean μ_B	Variance σ_B^2	Mean μ_T	Variance σ_T^2		
48.2%	0.053	51.6%	0.037	0.033	0.321

* Student's t-test: Two-Sample assuming equal variances, n = 160

P. Steif, "Concept Assessment Tool for Statics (CATS)," 2010. [Online]. Available: http://cihub.org/resources/statics

Preliminary Findings: Confidence

Table 2: Confidence Categories: Body-Based vs. Traditional

	Body-Based		Traditional		$(\mu_T - \mu_B)$	P(T<=t) Two-tailed*
	Mean μ_B	Variance σ_B^2	Mean μ_T	Variance σ_T^2		
Solving Open-Ended Problems	0.719	0.020	0.717	0.020	-0.001	0.949
Math/ Science Skills	0.717	0.022	0.717	0.025	0.001	0.983
Expertise	0.649	0.042	0.624	0.048	-0.024	0.484
Career-Fit	0.692	0.042	0.636	0.050	-0.056	0.108

* Student's t-test: Two-Sample assuming equal variances, n = 151

S. Sheppard et al, "Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (CAEE-TR-10-01)," Center for the Advancement for Engineering Education, Seattle, WA, CAEE-TR-10-01, 2010.

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Preliminary Qualitative Themes

1) Students resistant to real-world problems if they don't feel grounded in their conceptual knowledge first

"I need a well-defined toy"

2) Book problems reign supreme – students feel knowledge comes from the book, not from real-world experiences

"I know I can do the math and solve the problems, but I don't know what's actually going on at all."

"This seems pointless because in textbook problems, we never solve for problems like this."

3) Statics is challenging: Emotional responses to difficult problems

"Trig is hard"

"This makes me mad!"

Preliminary Conclusions

1. No statistically significant differences between Body-Based and Traditional cohorts on the CATS
   - Type of example had no apparent effect on outgoing conceptual knowledge
2. No statistically significant differences between Body-Based and Traditional cohorts on in any Confidence Categories
   - Including Professional Role Confidence
3. Students experience difficulty with ambiguity, uncertainty, and real-world problems
   - Value structure in trusting textbook problems to prepare real-world problem solving

Future Work

- Compare Fall 2012 cohort performance on CATS with past and future cohorts
- Understand how and why students value different types of knowledge differentially as novices: textbook vs. real-world vs. practical skills
- Investigate connections to how students negotiate and develop hierarchy and status as young engineers and the implications of this status structure on retention

Questions?

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- Contact: janet.tsai@colorado.edu

- Selected References

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4. S. Sheppard, S. Gilmartin, H. L. Chen, K. Donaldson, G. Lichtenstein, O. Eris, M. Lande, and G. Toye, “Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (CAEE-TR-10-01),” Center for the Advancement for Engineering Education, Seattle, WA, CAEE-TR-10-01, 2010.
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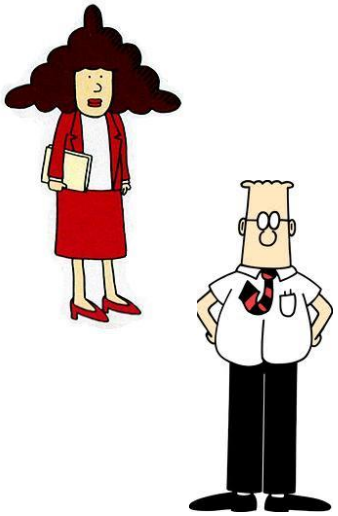
6. P. Steif, “Concept Assessment Tool for Statics (CATS),” 2010. [Online]. Available: http://cihub.org/resources/statics
7. P. Steif and A. Dollar, “Relating Usage of Web-Based Learning Materials to Learning Progress,” in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*, San Antonio, TX, 2012.

Appendix – Survey items

- APPLES Confidence in Math and Science Skills
  - *Confidence: Science ability*
  - *Confidence: Math ability*
  - *Confidence: Ability to apply math and science principles in solving real world problems*
- APPLES Confidence in Solving Open-Ended Problems
  - *Creative thinking is one of my strengths*
  - *I am skilled at solving problems with multiple solutions*
  - *Confidence: Critical thinking skills*



- Professional Role Confidence: Expertise Confidence
  - *As a result of my engineering courses:*
  - *Developing useful skills*
  - *Advancing to the next level of in engineering*
  - *My ability to be successful in my career*
- Professional Role Confidence: Career-Fit Confidence
  - *As a result of my engineering courses:*
  - *Engineering is the right profession for me*
  - *Selecting the right field of engineering for me*
  - *Finding a satisfying job*
  - *My commitment to engineering*

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Appendix – Summary of Recitations

Week/Topic	Traditional Recitation Examples	Body-Based Recitation Examples
1 – Vector Review	• Icebreaker and team building	• Icebreaker and team building
2 – 2D Force Systems	• Incline Plane • Spinning Plate • Couples in Mechanisms	• Simple Balancer • Moments in the Body • Couples on a Chair
3 – 2D Equilibrium, Part 1	• Brainstorm 2D Contact Examples • Broken Lecture Hall Desks	• Brainstorm 2D Contact Examples • Common Injuries in Snowsports
4 – 2D Equilibrium, Part 2	• Create, Swap, and Solve Statically Determinate and Solvable 2-D Equilibrium Problem	
5 – 3D Force Systems	• Leonardo DaVinci's Cam Hammer • 3D Moments in Toys	• 3D Coordinate system in the body • 3D Moments opening a Jam Jar
6 – 3D Equilibrium	• Brainstorm 3D Contact Examples • Robotic Arm 3D Equilibrium Problem	• Brainstorm 3D Contact Examples • Push-Up (human arm and shoulder) 3D Equilibrium Problem
7 – Trusses, Method of Joints	• Craft Stick Pin Joint to illustrate compression/tension	• Squeezing/pulling a racquetball through the forearms to replicate a joint
8 – Trusses, Method of Sections	• Santa on roof as point load	• Weightlifter with barbell as point load
9 – Frames and Machines	• Folding Chair (multiforce members)	• Human multi-force arm with bicep and tricep in tension
10 – Centroids	• Centroid of snow load • Snow Load on Minneapolis Metrodome	• Centroid of your own body • Centroid of human head model
11 – Distributed Loading	• Reaction board: distributed loading of everyday objects	• Reaction board: distributed loading of your own body
12 – Review for Exam #2	• Conceptual Review Game	• Conceptual Review Game
13 – no class		
14 – Friction	• Friction Predictions, box on incline plane with varying friction angle	• Friction Predictions, person on incline plane with varying friction angle
15 – Review for Final exam	• Conceptual Review Game	• Conceptual Review Game