Students' Microscopic Models of Friction: A First Look*

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RESEARCH QUESTIONS

- What are the existing models of introductory college physics students regarding friction and related phenomena?
- How do students build and use models in explaining common everyday phenomena related to friction?

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METHODOLOGY

- Semi-Structured Clinical Interview [1]
  - ⇨ 2 sessions (one hour each)
  - ⇨ Videotaped
- Interview Protocol
  - ⇨ Pilot-tested with 1 grad and 2 undergrads.
  - ⇨ Main Issues:
    - Surface at Different Length Scales
    - Cause of friction at the atomic level
    - Lubricating Mechanism of Oil

    Focus of this Talk
    - Why Static > Kinetic Friction
    - Friction on microscopically smooth surfaces

[1]Piaget (1929)

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METHODOLOGY

- Phenomenographic Analysis[2,3]
  - Categories emerged from students' responses.
- Thematic Analysis[4]
  - Themes emerged from categories in different contexts.

[2]Marton (1986) [3]Svennson & Theman(1983)
[4]Bogdan & Bilken (1998)

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The Participants of the Study

Major	No. of Students
Mech. Engineering	4
Secondary Education	3
Computer Science	1
Marketing	1
Microbiology	1
Undecided	1
Total	**11**

⇨enrolled in Conceptual Modern Physics (Spring 2004).

⇨had at least one semester of college physics.

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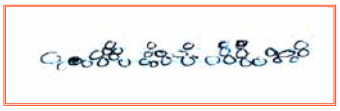
RESULTS

Surfaces at Different Length Scales

- If we keep zooming in we'll eventually get into the atomic level where we'll see individual atoms. (11 students)
- Surfaces have peaks and valleys even at the atomic level (7 students).



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Models Used to Explain (Static) Friction

Intertwining/Interlocking (5 students)

"…when I try to move it I got to pull them out so there will be some friction because there will be some **particles getting intertwined** like that (fingers of hand intertwining)"

Bonding Model (2 students)

"well I would say **friction is the bond between the atoms** I don't know if that's electronic, or ionic bonding"

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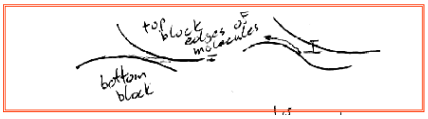
Models Used to Explain (Static) Friction

Rubbing/Hitting/Sliding (3 students)

"they are **touching** but they don't interact any more than just the **physical contact**…..one of them is moving and one of them isn't moving so they **rub together**"



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Models For Why Static > Kinetic Friction

Getting Smoother (1 student)

"The way this works basically is it is **more rough when it wasn't moving** than when it was."

Fewer Bonds (1 student)

"When it has started moving, let's say they might **not** have **enough time to form** that (**bond**) one and that (bond) one. So there's less number of bonds to be broken."

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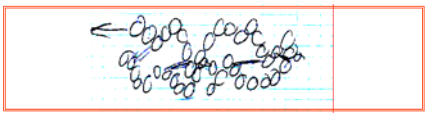
Models For Why Static > Kinetic Friction

Changing Downward Force (1 student)

"when it is at rest there's more pressure between the atoms….when it **starts moving you have less force pulling down**"

Skimming Over the Top (4 students)

"When you're moving it **they're gonna be not as intertwined**...it's gonna be like coming across and doing that (hand moving past the other)"



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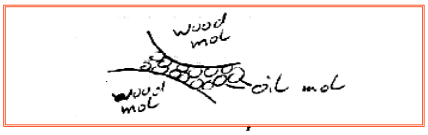
With Lubrication (Oil)

Ball Bearing (2 students)

"I think it might be possible that they move past one another easier but it could be that maybe oil molecules roll"



Fewer/Weaker Bonds (1 student)

"They **don't exhibit as much intermolecular bonds** between each oil molecule than between oil and wood molecules so they can move past one another easier than the wood on wood."

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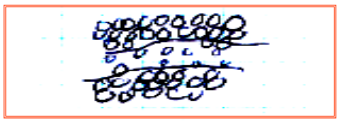
With Lubrication (Oil)

Reduction of Bumps and Valleys (1 student)

"Oil is not solid.. if you draw it **forms like a uniform line** between the two…in a sense makes it lot more flat to where nothing can stick out and go against a stuff as it went by."

Floating Model (3 students)

" oil will help **separate** these **bumps and valleys** such that they don't have to interact with the full scale"



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EMERGENT THEME

Macroscopic Ideas in Microscopic World

- Friction is due to mechanical interactions
  - meshing up of bumps and valleys
  - rubbing of atoms
  - downward force that presses surfaces together

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TRANSFER IS UBIQUITOUS

Students transfer..

- daily experiences
- knowledge from previous science courses
- previous explanations

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Thank You!!!

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