

THE COMPASS PROJECT
www.berkeleycompassproject.org



Berkeley
UNIVERSITY OF CALIFORNIA

Building Modeling Skills and Developing Science Identity in Physics Freshmen

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What is Compass?

The Compass Project is an **APS award-winning**, **student-founded** and **student-run** organization in the physical sciences at UC Berkeley.

Its goal is to **support and retain students** (especially those traditionally **underrepresented**) by creating a **unique, diverse environment** that blends teaching, learning, mentoring, leading, and community building.

Among Compass undergrads, 45% are women, 30% are URM, and 20% are first-generation college students. 90% have graduated with or declared a STEM major.



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Components of Compass

- Freshman course sequence
 - Summer Program
 - **Introduction to Modeling** (Fall)
 - Introduction to Measurement (Spring)
- Transitioning to Berkeley Physical Science (for transfer students)
- Frontiers of Physics (for upper-division students)
- Mentoring Program
- Research Lecture Series
- Office Hours
- Leadership in Compass



Introduction to Modeling

Structure:

One 2-hour class/week for 14 weeks, 16-20 freshmen, 2 instructors.

Course content includes:

- a unit on model-building via the **ray model of light**
- an **independent research project**
- weekly **self-evaluations** and related discussions

Goals:

Remove barriers to persisting in STEM & build research skills by developing:

- an understanding of the **nature of science**
- a **science identity** as a member of a community of practice
- a **growth mindset**



Nature of Science

Ray model of light:


- Through small-group discussion, experimentation, and class-wide consensus-building, students develop a model for light propagation.
- Students reformulate their ideas about the “scientific method” based on their experiences studying light.
- This process helps students understand what models, how to construct them, and how to use them to answer questions.



Science Identity

Independent research project
(2nd half of semester):

- Students form 2-3 person teams supported by a graduate student research advisor.
- Choose and answer a question (e.g., how does chalk skip on a blackboard) with model-building and experiments.
- Present results through a paper and a poster




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The Physics of Chalk Skipping

Undergraduates, UC Berkeley

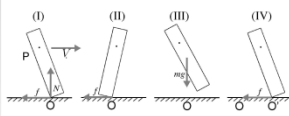
Mentored by _____



Abstract

The motion of a piece of chalk skipping over a blackboard surface is considered and a simplified description of such collisional process is proposed. The frequency of bounces is estimated by considering dynamics of the chalk.

Assumption



Consider a cylindrical piece of chalk, with length L and mass m , held at pivot point P with a distance D from its bottom. The angle between the piece of chalk and the vertical direction is $\theta(t)$, and that $\theta_0 = \theta(t_0)$. An external force \mathbf{F} applied at P drags the chalk across the blackboard surface. Here we make a reasonable assumption that \mathbf{F} is applied to keep the translation velocity \mathbf{V} a constant, and also create a restoring torque on the piece of chalk. By analyzing the videos of skipping motion from a high speed camera, we derive an analytic model, which divides one bounce cycle i.e. the process between every two consecutive collisions between chalk and blackboard, into four phases of motion. These phases are shown in Fig. 1. I) The chalk starts rotating clockwise with angular velocity ω around O from its equilibrium position. II) At time t_1 , the chalk

Result

The model described in Assumption yields out the following equation:

$$T = \frac{D}{V} \left[\ln \left| \sec \left(\frac{\omega_0 N}{K} \right) + \tan \left(\frac{\omega_0 N}{K} \right) \right| + C \right] + \sqrt{\frac{2 D f \cos \left(\frac{\omega_0 N}{K} \right) - \cos \theta_0}{g}}$$

Where C is given by $C = \ln \left| \sec \theta_0 + \tan \theta_0 \right|$ And the frequency is $\nu = \frac{1}{T}$


Unfortunately, due to the nature of our apparatus, it is unrealistic for us to make precise comparison between the mathematical outcomes and the collected data. However, we can at least match the increasing/decreasing tendency for T , in relation to V , N and D . By taking partial derivatives, we can show that,

Fig. 4 shows a decreasing relation between the velocity and frequency, which asserts with derived equation, $\frac{\partial \nu}{\partial V} \sim B, B \in \mathbb{R}^+$

Fig. 5 shows an increasing pattern between the N and frequency, which asserts with derived equation, $\frac{\partial \nu}{\partial D} < 0$

Fig. 6 shows a decreasing pattern between D and frequency, which asserts with derived equation, $\frac{\partial \nu}{\partial N} > 0$

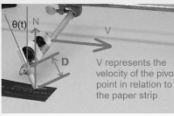
Methods



To describe the chalk skipping motion quantitatively, we introduce the frequency of bounces, $1/T$, which is defined to be the number of bounces per second. We want to find a function $1/T$ such that,

$$\nu = \nu(V, N, D)$$

An apparatus as shown in Fig. 2 is designed to conduct experiments. Data retrieved from repeated experiments are analyzed to build an approximate model. During each trial, we record the bouncing sounds made by the chalk and by inspecting the sound wave diagrams we obtain the average time between every two bounces, i.e. the period T .



Growth Mindset

Two components:

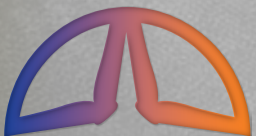
- Readings and discussions on the nature of intelligence, failure, and success
- Weekly self-evaluations based on rubric (example below), with written instructor responses

Skill	Questions to ask yourself	Beginning	Developing	Succeeding
Persistence	<ul style="list-style-type: none">• What do you do when you're frustrated?• Do you independently pursue understanding?	I tend to try one or two things. I give up more easily than I should.	I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help.	I look for new ways to think about the problem. I find a way to persist when appropriate.
Self-compassion	<ul style="list-style-type: none">• When you're having difficulty with something, how do you feel about yourself?• Do you make productive use of failure?	I have trouble with feeling like a failure, and these feelings often make me feel like giving up. I'm my own worst critic.	I am sometimes overly critical of myself. I tend to ignore feelings of failure rather than using them to improve.	I acknowledge my difficulty, but I don't let it define how I feel about myself. I act kindly towards myself and view failure as an opportunity for self-improvement.

This rubric is adapted from work by Jon Bender and is licensed under the Creative Commons Attribution-ShareAlike 3.0 Unported License (<http://creativecommons.org/licenses/by-sa/3.0/>)

Thanks!

More questions?
Come see me at my poster at
the PERC poster session.



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Demographics & Retention

	Compass (%)	Physics Dept (%)
Female	45	16
Chicano/Latino	26	7
African American	5	0.5
Native American	1	0.5
First Generation	19	N/A

