Final Project Topics

Overview

This is a list of suggested topics for your final projects. If any of these sound particularly interesting to you, great! You should find some other people to work on that topic with you, and make a group. If none of these sound thrilling, you are free to propose your own topic, which will be approved by course instructors as long as (1) you can find 1 or 2 other people who are interested in working on it and (2) it is possible for you to make meaningful progress on in the time you have. It will help if your proposal includes a few specific starting points for your work.

Remember that although there may be many questions out there that intrigue you, the best research questions are the ones that you have some idea how to begin to answer in the time available. While string theory may seem like the coolest thing ever, it will take longer than the weeks you have to get comfortable with the basics and compute something yourself. Please note that this project is **not** a book report, so summarizing an explanation that's given in a textbook is **not** sufficient, even if you understand it and recast it in your own.

Suggested Topics

Craters on the moon

We can observe craters on the moon very easily. A sensible question to ask is what sort of fingerprint of their creation is left in these craters. It is not a good idea to fire things at the moon and examine the result. Thus, we would like to create some sort of physical simulation for this environment and do experiments on it in order to explore the factors which are relevant to crater creation. Can we determine what sized object made any given crater on the moon?

Ray model of sound

The ray model of light is effective in many circumstances, and we have explored many of its repercussions. This leads us to ask: is a ray model a sensible model for sound? Can we do some tests to find situations in which it is or is not appropriate? Can we determine a way to predict when the model would apply to a new situation?

Air resistance

Psht, we all know that physics happens in a vacuum... Right? Jokes aside, air resistance is an important phenomenon for our air-filled planet. We would like to develop a basic quantitative model of air resistance which applies to simple objects. This is an extremely broad topic, so your group should focus on one experiment until you feel that you have a satisfactory explanation for it. Can we determine conditions on the limits of our model?

Friction of layers

Many of us have studied static and kinetic friction in intro physics courses. However, this concept of friction only deals with two solid materials which are not being modified by the frictive process. We would like to better understand what happens when we have a special interface between two materials, in cases such as thin water films between ice skates and ice or writing with a pencil, ball-point pen, or fountain pen. Is there a sensible way to describe the mathematics of the forces exerted in these situations, and are there limiting cases which they revert to the simple coefficient of friction model?

Stickiness

Some things in the world seem to snap together much more than other things, and once separated, seem to no longer pull on one another: Post-its, Velcro, fridge magnets, fun-tack, rubber cement… the list goes on. A simple model for this would be binary – that two things are either stuck together or not. This model is not very descriptive! We would like to make qualitative and quantitative improvements on that model using empirical observations. When can we call two things stuck? Can we create categories of sticky things?

Cracking towels (or whips!)

A whip-crack is a very iconic phenomenon. It happens because a part of the whip is able to travel faster than the speed of sound. But, as it turns out, it is not easy to make something travel faster than the speed of sound: human body parts certainly cannot do it! We would like to figure out how a person's body mechanics combine with the mechanics of the whip to break the speed of sound. Can we infer the answer by modeling, and then use an experiment to verify? Can we determine what properties of the whip control how easy it is to crack? Can we crack other objects, like a wet towel, and is the mechanism the same as for a whip?

Physics of skipping

There are a couple of striking (pun intended) phenomena involving things skipping along surfaces. If you hold a piece of chalk lightly and at the right angle, it will bounce along the chalkboard as you write with it. If you toss a flat rock fast enough and at the right angle, it will skip along water. There is a Basilisk lizard which can run along water by slapping its feet onto the water. These phenomena, though not necessarily identical in cause, could all be explained by a single principle that has to do with quickly and repeatedly striking a surface. Can we come up with a way to decide when an object will skip off of a surface rather than just slide across it? Can we control skipping rates, and can we find practical applications of skipping?

Splashing into mixed media

If you've ever cannon-balled into a pool, you know that the response is a giant splash which gets your friends all wet (http://tinyurl.com/giantsplash). The key here is that the splash that matters is not the one when you enter the water, it's the one which explodes up after you've been in the water for a second. But what would happen if the guy in the video tried these things in a pool of something else, like blended jello, or quicksand? Or what if he belly-flopped instead of cannon-balled? Or what if he threw in a bowling ball instead of himself? We would like to better understand the splash phenomenon, especially as the medium which splashes starts to change. Can we predict the height of the splash if we know the object we are dropping and the medium that it's falling into?

Bubbles!

Bubbles are everywhere: in carbonated drinks, in water that's just about to boil, and in the tub when you take a bubble bath. But what determines the properties of bubbles: their size, their shape, and how fast they rise (or sink!)? What happens when two bubbles combine? Can a bubble split into two smaller bubbles? See if you can come up with a model that can describe the behavior of bubbles.

Piles of salt

Next time you're at home, pour a bunch of salt onto your kitchen counter. One thing that that you might notice is that the angle of the side of the pile never gets above a certain value; there will be an avalanche once it gets close. What accounts for this maximum angle? Does the angle depend on whether we are pouring salt, sugar, sand, Legos, or ping pong balls? Can you predict which materials will have a larger or smaller angle?

Shaking granola (or kitty litter)

If you've ever eaten granola, you might have noticed (and been annoyed by!) the fact that the largest pieces of granola end up at the top of your granola package. If you've ever emptied a litter box, you might have noticed (and been happy about!) the fact that when you shake the litter box, the bits that you are trying to collect end up at the top. Are these effects related, and if so, what accounts for them? Can we predict when various objects will rise to the top in similar situations?

Other possibilities

Here are some other ideas that may be problematic but still sound cool. If you can turn one of these into a doable project, go for it!

- **Sunspots:** It's possible to observe spots on the surface of the sun, whose motion can tell you something about the movement of the sun's surface. There seem to be two challenges with this project: (1) it's nontrivial to observe sunspots, although one of us may have access to equipment that can do it and (2) it's difficult to model a fluid, although this might be a case where a physical model, like a spinning water balloon or a fluid swirling in a beaker, would be useful.
- **Greenhouse effect/rising water level:** We cannot think of a simple enough experiment that we could do to study this, so it may be too scientifically ambitious for this course.
- **Directionality of hearing:** The question here could be "Why is it that you can tell which direction a sound is coming from?" The trouble is that the answer is easy to look up, and we are trying to avoid "book report" projects. Maybe it's possible to come up with a question that is related but not so well-understood?
- **Color vision:** The problem here is a combination of directionality of hearing (you can just look up the answer to why we can see in color) and the greenhouse effect (doing a straightforward experiment and constructing a simple model seems difficult). Still, this is a cool topic that could be shaped into something doable.