Physics 9 — Wednesday, August 29, 2018

- Have you ever had a friend telephone you from a completely empty apartment — no furniture, bare wood floors, etc.? Did you notice almost immediately? How could you tell?!
- Have you noticed that the Amtrak announcements at 30th Street Station are nearly unintelligible? Why?!
- Why do a broadcast studio, a classroom, a concert hall, and a cathedral all “sound” different?
- Ask your neighbor what he or she thinks is a key difference between a room that is acoustically “live” and room that is acoustically “dead.”

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- Ask your neighbor what he or she thinks is a key difference between a room that is acoustically "live" and room that is acoustically "dead."
- Then see if you and your neighbor agree on which kind of space sounds more "live" (or **reverberant**) — a big space or a small space? What about a space having hard surfaces vs. surfaces covered in soft material? [Play sound samples.] `https://www.youtube.com/watch?v=cvr-TRu0zqM`
- Hold that thought for a moment — we'll come back to it.

- Physics 8 and 9 are "Physics for Architects," a two-part college physics course, whose two parts we teach in alternate fall terms: Phys8 (2017), Phys9 (2018), Phys8 (2019), etc.
- In Physics 8, we study Newton's laws of motion. We learn to describe motion with terms like time, position, velocity, acceleration, momentum, energy, power, force, and torque.
- Then Physics 8 spends 4 weeks using force and torque to analyze parts of structures: cables, trusses, beams, etc., and finishing with vibrations ("periodic motion" / "oscillation").
- In Physics 9, we quickly review Newton's laws and vibrations, as a segue into the main topics: **waves, sound, light, fluids, heat, and electricity.**
- Physics 8 is not a prerequisite for Physics 9, but a few topics will assume you're familar with the mechanics concepts listed above (velocity, acceleration, force, energy, power, etc.).
- We emphasize the topics most relevant for ARCH majors.
- We try to make this course fun, interesting, and stress-free. You read, you participate in class, and you solve homework problems. No midterms or quizzes. No "curve." No labs.

- If you took Physics 8 last fall (or plan to take it next fall) its emphasis on forces, torque, vectors, etc. is most relevant to the "**Structures**" side of architecture.
- This fall, our studying **waves, sound, light, fluids, heat, and electricity** will be most relevant to the **"Environmental Systems"** side of architecture. A common theme will be the transformation of energy from one form to another.
- We think ARCH students will find these topics relevant, especially with today's emphasis on sustainable design.
- If you're not an ARCH student, we hope you'll find Physics 9 to be a fun, interesting, and stress-free way to satisfy the College's "Physical World Sector" requirement.
- You're welcome to take Physics 9 without having taken Physics 8, or to take Physics 9 first and then Physics 8 later. If you did not take Physics 8, we'll assume that you took "honors" high-school physics, so that you're familiar with Newton's laws of motion and with ideas like velocity, acceleration, force, energy, power, etc. — particularly **energy**!

A question to discuss (speaking of energy)

Which of the following contains more energy?

(A) One gram of chocolate-chip cookies

(B) One gram of TNT (the explosive trinitrotoluene)

A related question: how much energy is released when you "burn" (or metabolize) one gram of chocolate-chip cookies? The most convenient units here are dietary Calories: $1 \text{ Cal} = 4180 \text{ J}$.

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The table on the next slide comes from Chapter 1 ("Energy") of *Physics and Technology for Future Presidents* — which you should read tonight, if you have not done so already. Putting physics into a real-world context can give you a deeper and more intuitive understanding of concepts like energy, which are central to sustainable design.

Table 1.1 Energy per Gram

Object	Calories (or watt-hours)	Joules	Compared to TNT
Bullet (at sound speed, 1000 ft/s)	0.01	40	0.015
Battery (auto)	0.03	125	0.05
Battery (rechargeable computer)	0.1	400	0.15
Flywheel (at 1 km/s)	0.125	500	0.2
Battery (alkaline flashlight)	0.15	600	0.23
TNT (the explosive trinitrotoluene)	0.65	2700	1
Modern high explosive (PETN)	1	4200	1.6
Chocolate chip cookies	5	21,000	8
Coal	6	27,000	10
Butter	7	29,000	11
Alcohol (ethanol)	6	27,000	10
Gasoline	10	42,000	15
Natural gas (methane, CH_4)	13	54,000	20
Hydrogen gas or liquid (H_2)	26	110,000	40
Asteroid or meteor (30 km/s)	100	450,000	165
Uranium-235	20 million	82 billion	30 million

Note: Many numbers in this table have been rounded off.

So energy will be a recurring topic this semester, as we make our way through waves, sound, light, fluids, heat, and electricity.

Speaking of light (which we'll discuss a month from now), what does adding a mirror do for a small space? Where do objects in a mirror appear to be? If the mirror is flat, how far away do the objects in the mirror appear to be?

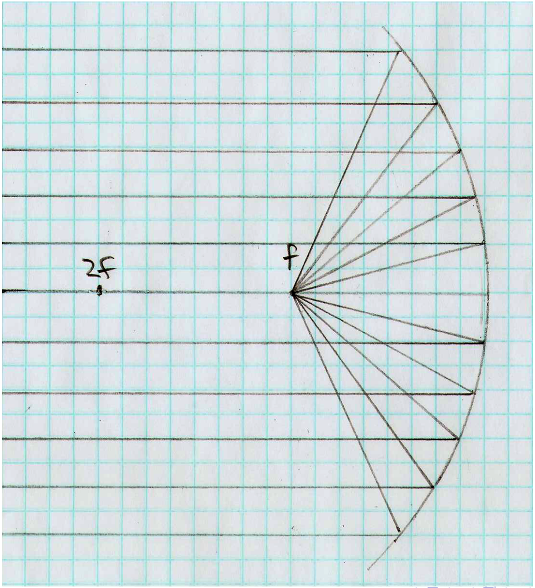
What does a ray of light do when it meets a mirror? What can we say about the angles?

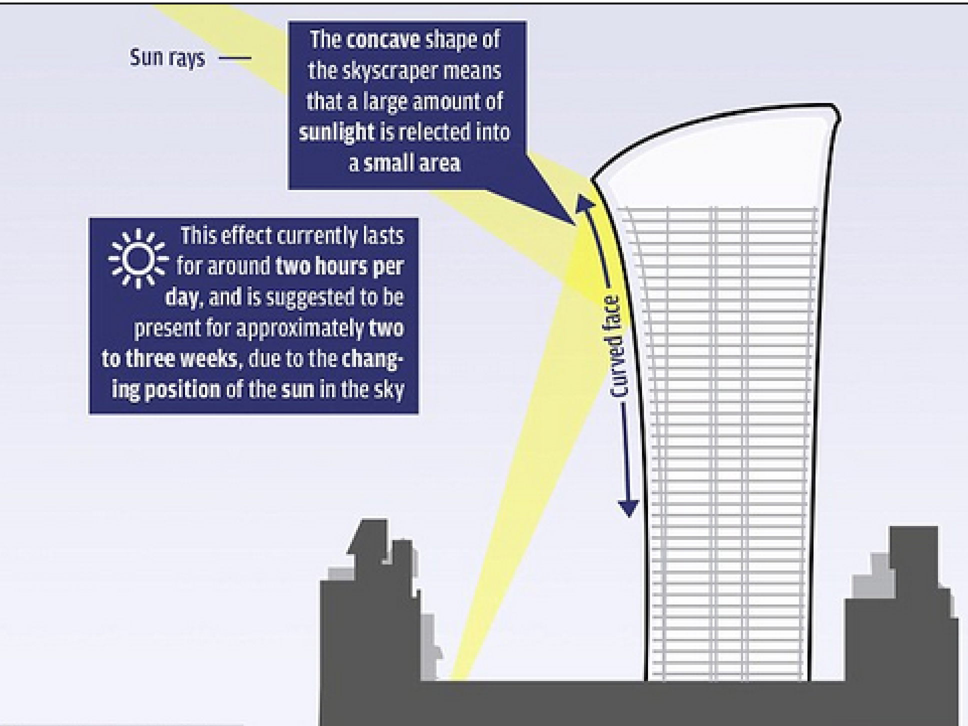
Can we "see" the path taken by a ray of light?

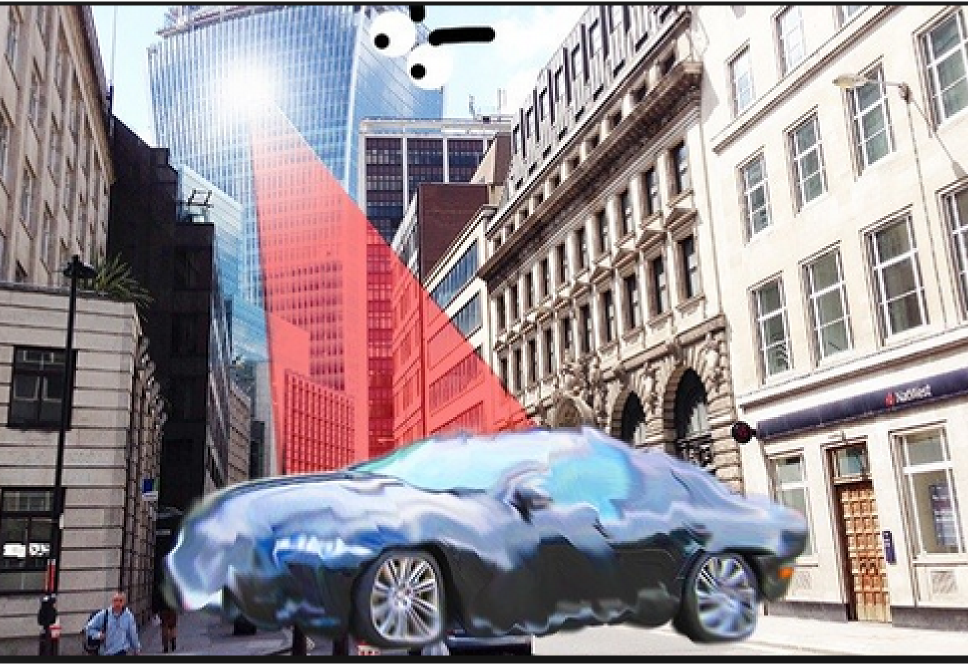
How does your eye decide where a ray of light comes from?

What if a mirror is not flat?

When we trace rays of light that meet a concave mirror, we see that parallel rays converge to a focal point. This is the mirror one uses for a close-up view when applying make-up or shaving.

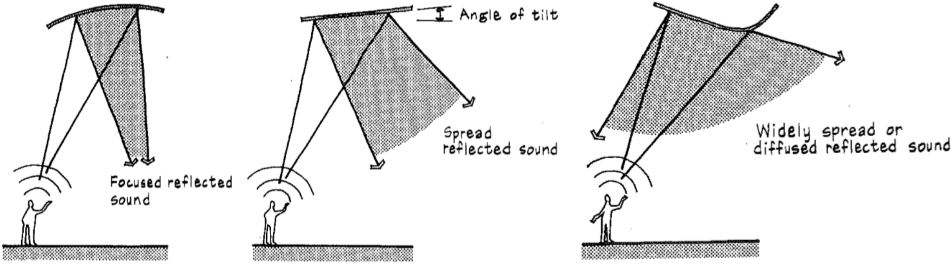



Sun rays
The concave shape of the skyscraper means that a large amount of sunlight is relected into a small area
This effect currently lasts for around two hours per day, and is suggested to be present for approximately two to three weeks, due to the changing position of the sun in the sky
Curved face

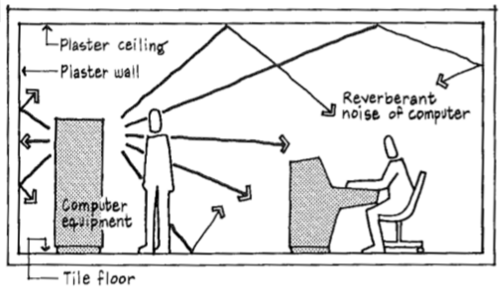


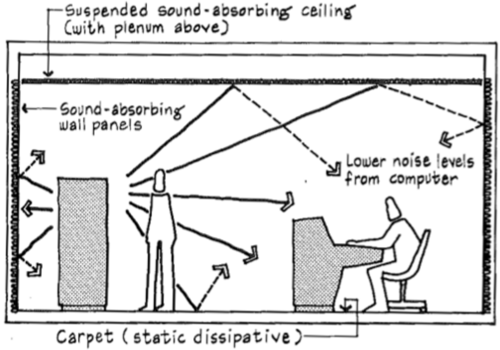
Just one example of the relevance of Physics 9 for architecture!
(Google "London walkie talkie building melts cars.")

The same mirror-like principle applies to sound — particularly high-frequency sounds, whose wavelengths are much smaller than the sizes of the surfaces that reflect the sound waves.



- Concave reflecting surface focuses reflected sound, causing undesirable “hot” and “cold” spots of loudness.
- In a good concert hall, the listener feels “enveloped” by sound arriving from all directions, with arrival times (for different paths) differing by less than about 0.030 seconds — which implies less than about 30 feet difference in path length.





Hard surfaces reflect sound, as a mirror reflects light.

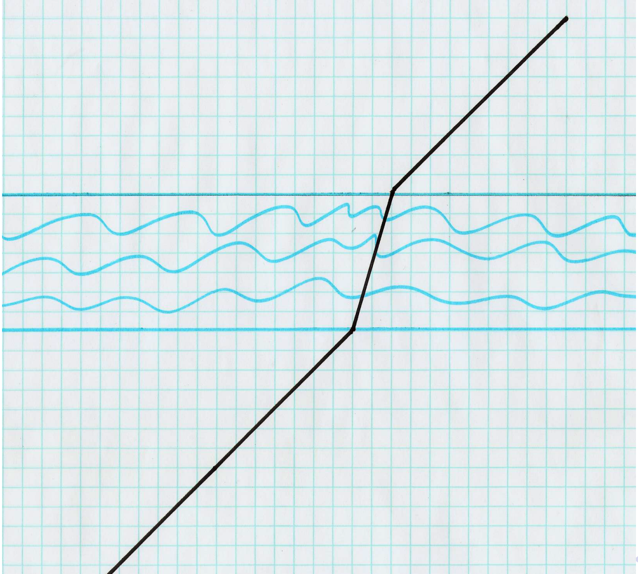
Soft or porous surfaces absorb sound, as a dark-colored surface absorbs light.

The less sound-absorbent the surfaces, the more times sound can reflect before its energy is diminished (dissipated into heat).

The larger the room, the longer it takes the sound to travel from one reflecting surface to the next reflecting surface.

Large space with hard walls has longer **reverberation time** than small space with absorbent walls.

We'll also see, in late September, that light travels more slowly in glass (or in water) than it does in air. But light follows the quickest path. If you imagine a backpacker on a trail that crosses a river diagonally, you'll see the principle by which a lens works.



OK, let's move on to the syllabus:

positron.hep.upenn.edu/physics9

And the page of "reading response" forms:

`positron.hep.upenn.edu/jitt`

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- Read Giancoli's chapter 4 for Friday (on Canvas): it's a review of Newton's laws of motion ("dynamics").
- Answer online reading questions by Friday 9am: `http://positron.hep.upenn.edu/wja/jitt/`
- And do the same for PTFP chapter 1, if you haven't already.
- In case of technical difficulties, just email your answers to me: `Bill Ashmanskas <ashmansk@hep.upenn.edu>`
- Course web page is `positron.hep.upenn.edu/physics9`
- Slides, etc.: `positron.hep.upenn.edu/physics9/files`
- First weeks' reading materials will be online on Canvas: `https://canvas.upenn.edu/courses/1422187`
- Most Fridays (starting 9/14): homework problems due; other class days: assigned reading due, with online questions.
- Homework help (starting Sep 12): Wed 4-6pm (Bill) in DRL 4C6, and Thu 6:30-8:30pm (Grace) in DRL 2C8.