Physics 8 — Monday, December 9, 2019

- Practice exam: If you turned it in Friday, I'll email it back to you, graded, this evening. Otherwise, I'll return it to you on Wed. If I don't have your exam by 5pm today, your score is zero, with no exceptions, so that I can put solutions online tonight.
  `http://www.hep.upenn.edu/~ashmansk/drl_1w15.jpg`
- 3×5 card + "dumb" calculator on final exam (no internet, no reference materials except 3×5 card)
- Review session (optional) Wed 2–4pm DRL A6
- 4 previous years' exams & practice exams are at
  `http://positron.hep.upenn.edu/p8/files/oldexams`
- Extra credit options (until Thu, Dec 19):
  - O/K ch9 (columns)
  - Citigroup Center "structural integrity" podcast
  - Learn about Taipei 101 "Tuned Mass Damper"
  - Mazur ch13 (gravity), ch14 (Einstein relativity)
  - Code something in Processing or Py.Processing
  - Go through tutorials to learn Wolfram Mathematica
  - Go through Prof. Nelson's python data modeling book
  - Suggest something else: `https://youtu.be/Wiln4BUOzDg`
- If you have your clicker here, please turn it in after class.

(avoiding) resonance in structures

https://99percentinvisible.org/episode/supertall-101/

Taipei 101 “Damper babies” speaking in their made-up nonsense language about the Tuned Mass Damper
https://youtu.be/1kwMnBOPAVQ

Short documentary by actor/presenter includes “eating soup on moving bus” demo of non-inertial reference frames, and interview with the Taipei 101 architect including architect’s demo that resembles our in-class meter-stick demos:
https://youtu.be/OSEYOavsKxA

Physics can give us new insights into the everyday world. We should go through this video a second time at end of semester.

https://www.youtube.com/watch?v=XfZFuw7a13E https://www.youtube.com/watch?v=XfZFuw7a13E&t=35

- 0:35 — impulse
- 0:43 — rotational inertia, torque
- 0:51 — torque, periodic motion, velocity, projectile motion
- 2:53 — friction, circular motion, projectile motion (173 s)
- 3:30 — center of mass (210 s)
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(avoiding) resonance in structures [ARCH 535]

Lateral Loads and Stability

Natural period of oscillation

- harmonic motion
- period of a structure is proportional to weight and inversely proportional to stiffness

Lateral stability of structures

- braced frame
- rigid frame
- shear wall

Code and Safety in Design

- factor of safety
- resilience

Design strategies

- absorb energy in the structure (flexible joints, shock absorbers) (example Bell Atlantic, west coast buildings)
- tuned mass dampers (CitiGorp)
- building shape (Burj Khalifa)

Lateral Stability in Structures

I list at the link below some (totally optional) questions about the format of the course. Please take a look. If you're willing to think about them, you can answer either via the usual response form or else include your thoughts anonymously with your course review. E.g. type anonymous comments now and copy/paste them later.

http://positron.hep.upenn.edu/q008/?date=2019-12-06

- About how many hours did this practice exam take you?
- Are there particular problems from [the practice exam] or topics from the course that you'd like me to go over in the review session before the final exam?
- What topics did you enjoy most and least from this course? Will anything that you have learned in Physics 8 be useful in your future career? Would you adjust the balance between covering traditional physics topics and covering applications to architectural structures? As a result of feedback on this question from past years, I have dropped Mazur's chapter 13 (gravity) and substantially expanded the Onouye/Kane segment of the course.

- Do you have any comments on the format of Physics 8 (how to use classroom time, whether to have midterms or quizzes, how much emphasis to place on homework and reading)? Do you have suggestions for formatting Physics 9 for next fall in a way that will help you to learn the material more readily or will make the course more engaging for you?
- Here is what I am thinking for reading assignments next time. I welcome your comments and suggestions! I like Mazur's non-traditional ordering of topics (momentum and energy before forces, focus initially on one-dimensional problems), and I like the conceptual half (the first half) of each of his chapters. But I think that the second half of each Mazur chapter, many students in Physics 8 aren't sure where to focus their attention. So I'm tempted to keep the first half of each Mazur chapter but to replace the second half with notes that I would write up to summarize the key results, with pointers to the textbook for longer discussions.

- For the Onouye/Kane book, I love the illustrations and the many architecture-related worked examples. But I think in many cases it would be nice to have a clearer explanation of the key results and how to use them. So I'm tempted to supplement each O/K chapter with my own notes summarizing the most important results. If I supply notes, you would read my notes carefully and then just quickly skim through the corresponding textbook material. Do you think that would be an improvement? Other suggestions?
- I'd like to make the reading go more efficiently for you, and better synchronize each week's reading to that week's classroom time. I'd like to distill the O/K material to the key ideas, simplify the discussion of beams, and add a short discussion of columns and of stone arches. I also want to expunge the non-metric units from most of the examples!

- If you have your clicker, please turn it in after class.
- Would 2 lectures @ 90 minutes work better? e.g. MW 3-4:30?
- Future "quiz" idea, to cover a topic from homework already done, graded, & handed back with solutions:
- pass 1: spend 5 minutes solving the problem on your own, and hand that in.
- pass 2: spend 5 minutes discussing & solving the problem with your neighbors, and hand in your copy of that group result.
- If you fix on pass 2 any mistakes from pass 1, you earn back 50% of the corresponding points you lost on pass 1.
- You would do this at the start of class, about once a week, while I'm setting up demos or handing back graded work.
- Another idea: try to make one question per reading assignment be some kind of simple calculation (similar in difficulty to Mazur's "self-quiz" questions) to help you test your understanding. Maybe Canvas would grade this automatically and would let you redo it until you get it right.

- what if we moved some of the HW problem-solving into class time, and moved some of the demonstrations etc into videos or animations?
- what if we blocked out an hour on fridays, potentially for some hands-on lab-like activity in class? (probably more relevant for physics 009.)
- how helpful would it be for me to replace a large fraction of the reading with my own typed-up notes, which would be more focused in content on what we emphasized during classroom time?
- for the current course content, assuming that we spend 3 hours a week together in some sort of classroom, what would be the best use of those hours?

- I really like the homework problems from this course. To me, the homework problems are the most valuable thing you do here, and I think that most of the problems we solve are a good fit. IMO, everything else I do is mainly to motivate you to solve & think carefully about the HW problems.
- It would help me if you could describe what niche this course fills for you, or what niche you'd like it to fill. Sometimes people suggest eliminating this course and having ARCH students take PHYS 150 instead. Sometimes people suggest having PHYS 8/9 be only one semester, not two. Sometimes people suggest adding "labs" or (preferably) hands-on versions of the demonstrations.
- I think that as long as enrollment stays roughly where it is now, it's advantageous to offer introductory physics courses tailored to the interests/needs of various groups of students.
- Anybody thinking of taking Physics 9? It was suggested to offer Physics 8 every year and eliminate Physics 9, but Prof. Farley and I both think the Physics 9 topics are quite valuable, even if they are less tangible than mechanics.

- By the way, the topics for Physics 9 can be summarized as:
- waves, sound, light, fluids, heat, electricity & circuits.
- Understanding these topics is relevant for environmental systems, energy efficiency, acoustics & soundproofing, mechanical & plumbing systems, etc.
  - If you've sat in an old DRL classroom while the medevac helicopter passed overhead, you know why a designer needs to understand sound propagation.
  - Since so much of what you do is visual, you're probably already curious about what light is and how it is emitted, reflected, absorbed, magnified, affected by passing through glass & water, observed by human eyes, etc.
  - If you've felt your ears pop when deep underwater or at high altitude, if you've marveled at the size of the Hoover Dam, or if you've seen the effect of a strong wind on the roof of a house of the wall of a skyscraper, then you may be curious how fluids (liquids and gases) work.
  - Since a key function of many buildings is to shelter occupants from variations in outdoor temperature, you may want to learn some of the physics behind temperature, heat, and energy.

- By the way, the topics for Physics 9 can be summarized as:
- waves, sound, light, fluids, heat, electricity & circuits.
    - Since it's difficult to imagine life in the modern world without electricity, you might be curious what volts and amps really are, or why so-called "high-tension" (really "high voltage") lines are used to transport electricity over long distances, or why an electrical outlet provides "alternating current," while a flashlight battery provides "direct current."
    - You might also be generally curious how electrical forces hold atoms together and are responsible for the chemical energy stored in food and fuel. Or how a rooftop solar panel converts sunlight into electrical energy.
- We are also tempted to make Physics 9 a more hands-on course than Physics 8. Sometimes Physics 9 is a smaller group, which makes it easier to be less formal.
- In 2016, we did some hands-on learning in class, e.g. by building and measuring some battery-powered circuits. We also spent a few classes learning to program tiny "Arduino" computers to let you create gadgets that can interact with the environment: blinking, sensing, producing sounds, etc.

- For the Physics 9 topics, there is much less need to spend a lot of time solving intricate homework problems. There are homework problems, but they are much less rigorous than in Physics 8.
- In Physics 8, we really want you to become highly skilled, through lots of practice, at working with forces, vectors, and torques/moments.
- In Physics 9, we want you to be aware of the many physical phenomena that affect a design: acoustics, light, the movement of air and water, heating/cooling, electrical power, electronic automation.
- So much of the reading takes the form of anecdotes that illustrate the relevance of the physics. In 2016 & 2018, we did this using “Physics and Technology for Future Presidents” by Richard Muller, which most students enjoyed. Next year we will probably supplement by writing up many real-world examples drawn from Richard Farley’s long experience in architecture/engineering practice.
- Also, Physics 8 is no longer a prerequisite for Physics 9.

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Course recap

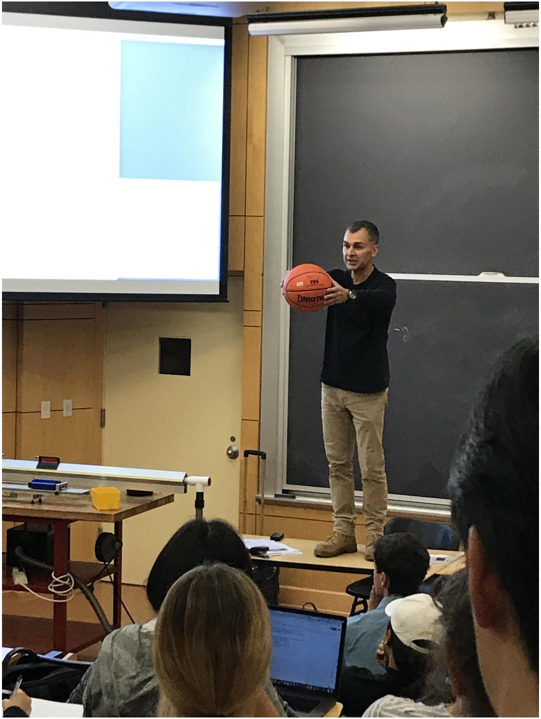
- We'll do a more technical recap at the review session. Here's my more philosophical recap of Physics 8.
- A key motivation for architects to study Newtonian mechanics is to enable you to go on to study architectural structures.
- Prof. Farley has told me several times that he wants students to enter his Structures course with a solid understanding of forces, vectors, and torque ("moments").
- Another motivation to study physics, which Richard Wesley likes to point out, is that undergraduate Architecture at Penn is set in a liberal-arts context. Breadth of knowledge is good.
- The "force" concept is notoriously difficult for students to learn. Even after you've learned how to solve homework problems using forces, it still takes a lot of thinking and practice to grasp Newton's three laws fully. Newton's laws are counter-intuitive: they defy your innate intuition.
- (1) Law of inertia. (2) $\vec{F} = m\vec{a}$. (3) $\vec{F}_{12} = -\vec{F}_{21}$.

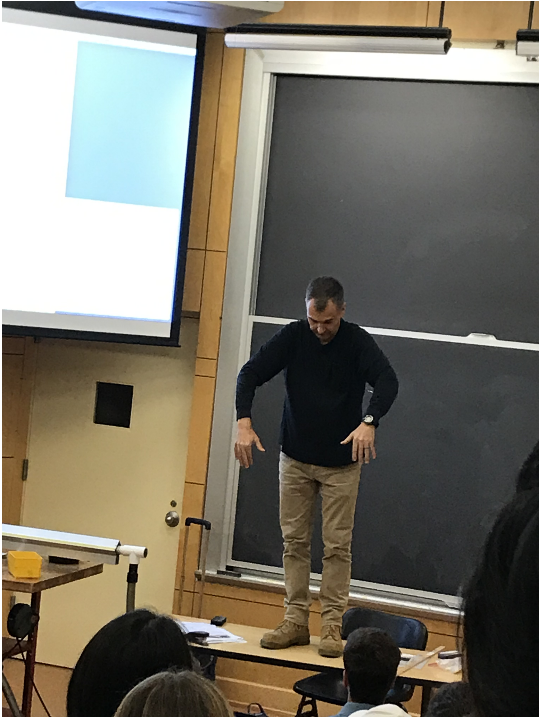
- (1) Law of inertia. (2) $\vec{F} = m\vec{a}$. (3) $\vec{F}_{12} = -\vec{F}_{21}$.
- If you told a little kid that if you do nothing to a moving object, it continues forever with the same direction and speed, the kid would not believe you.
- Even after you've learned calculus, it takes some time to get used to $\mathrm{d}^2x/\mathrm{d}t^2 = (1/m)\,F_x$.
- And you can find many examples of book authors who believe, incorrectly, that $\vec{F}_{12} = -\vec{F}_{21}$ stops being true if you put such a large weight on a table that the table collapses.
- The fact that force and acceleration are vectors makes all of the above even more complicated, since you're remembering trigonometry at the same time as you're learning forces.
- So we began by describing motion, in 1D, to grasp position, velocity, and acceleration. Then we studied colliding objects in 1D, to cement the idea that when two objects interact, the motion of both objects is affected. We studied momentum, then energy, then finally forces and work. Probably different order from your first physics course.

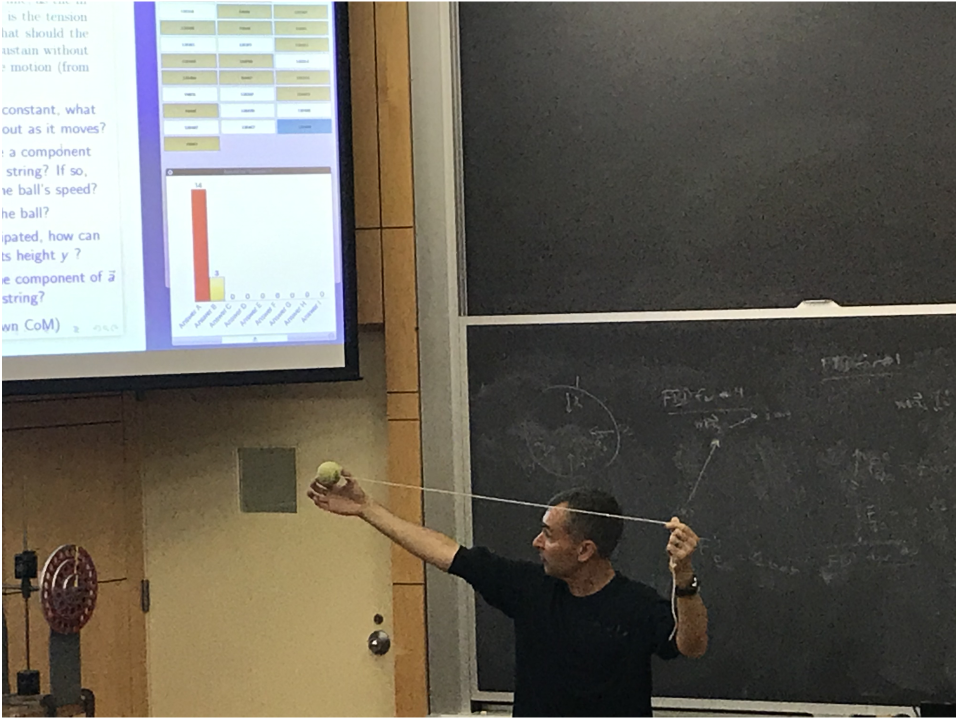
- Then we moved from 1D to 2D. Vectors/trigonometry!
- That let us model friction quantitatively. It let us solve some classic projectile-motion problems.
- Then motion in a circle, where we saw that "accelerating" does not have to mean "changing speed!" That let us understand the strange effects you feel on a highway offramp, or the tension in a string on which a ball twirls around.
- Finally we came to rotation and torque, which make acceleration and forces look easy by comparison.
- That gave us exactly the background we needed for our brief 5-week survey of architectural structures. We used the three conditions of equilibrium — again and again and again. We identified forces and their lines-of-action and drew EFBDs. We grew more and more accustomed to working with torques ("moments"), through example after example.
- Finally we finished up with periodic motion ("oscillation"), which is also relevant for structures.
- I hope that along the way, a lot of physics ideas have become much more comfortable and familiar to you.

- Teaching this course (5$\times$ so far) — discussing physics with you in person and by email, and working on solving physics problems with many of you — is a huge amount of fun for me. Doing this job doesn't feel like "work."
- I try to make this course interactive, so that I can adapt it to your interests, your questions, your learning styles. Student feedback has made this "your" physics course — more so than "mine." What I've learned from you will help to make this a better course for future students.
- I've tried to push you to learn as much as you reasonably could about the physics that I think will inform your intuition about the physical world in which your own creations will reside.
- My goal is to be a good "coach," rather than a kind of gatekeeper between you and grad school. Like other coaches, I can point you in the right direction, and offer help when you get stuck, but I can't do the learning for you.
- It has been a great honor to study physics with you this fall! Best wishes on your exams/reviews and in your careers!

If you're a senior, expect to see me applauding and shouting out your name from the Locust Walk gauntlet in the commencement procession. Email/text if you want a group graduation photo.



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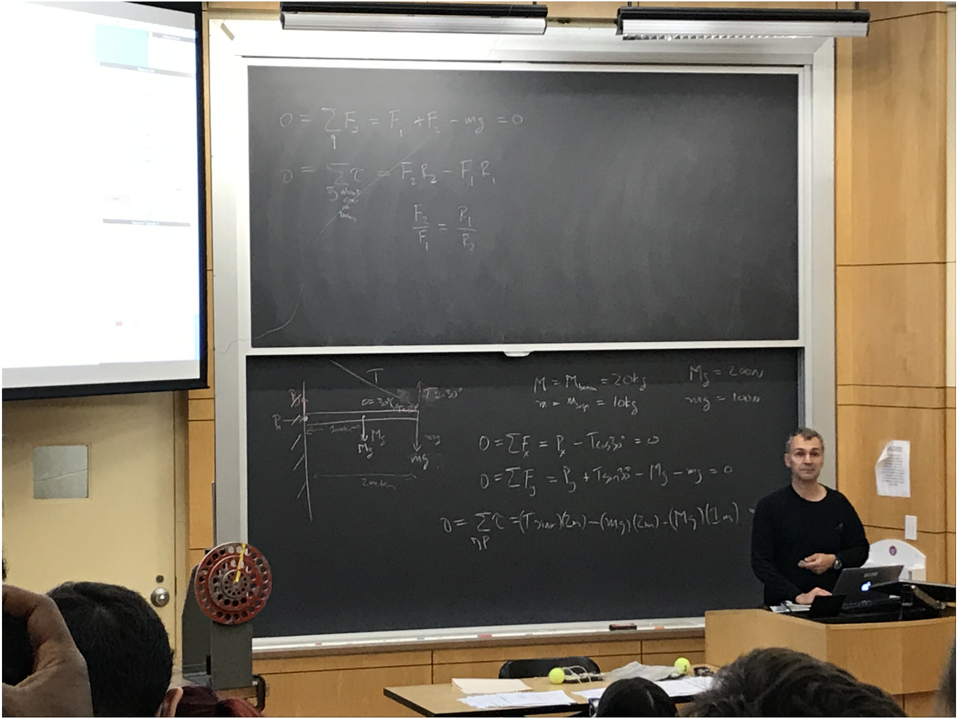

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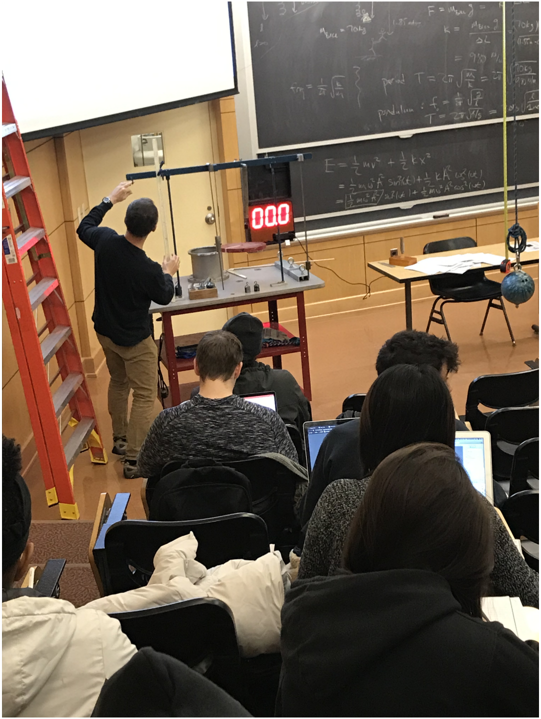
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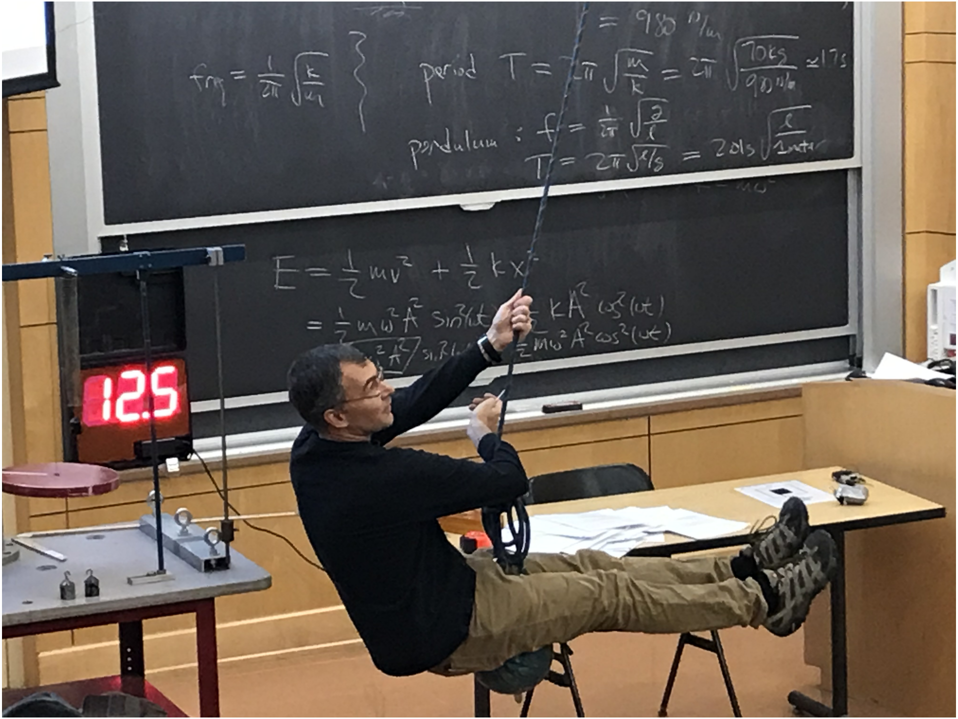
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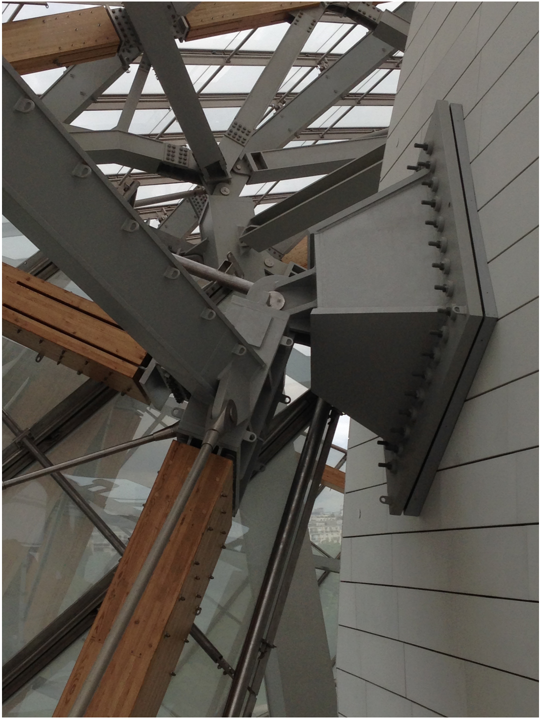

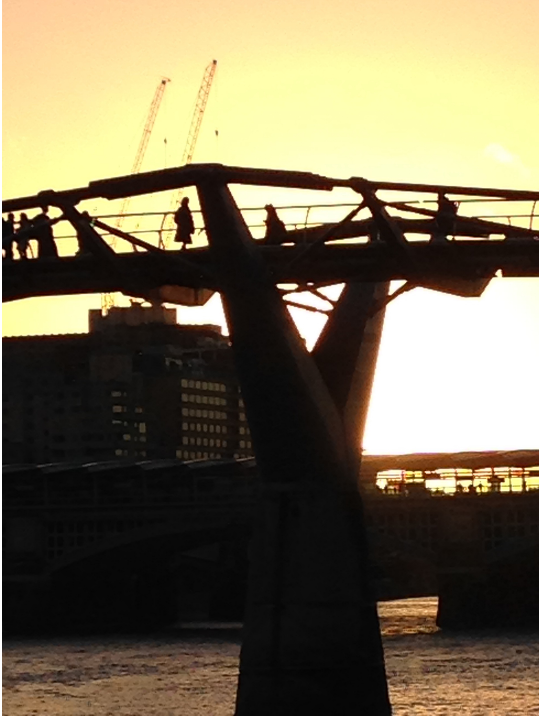

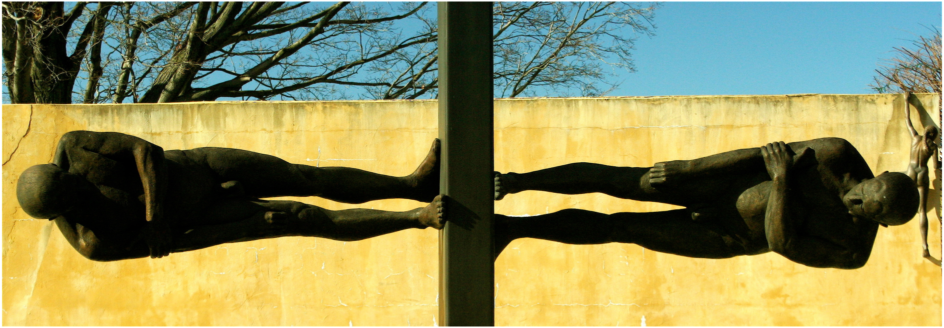

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