- worksheet: `positron.hep.upenn.edu/p8/files/ws24.pdf`
- 6 problems + 1 XC. If time runs out, Q6 will become XC.
- Be sure to double-check your final exam signup time slot on the online spreadsheet. If you are the only person for your time slot, it's OK, but please consider whether one of the slots with 1 or 2 people would work for you.
- I'll try to post the list of questions early next week.

Study and solve these problems, most of which closely resemble worksheet problems you've solved in class. Keep working until you are confident in your ability to solve each problem without looking at written solutions (your own, mine, or someone else's). Feel free to discuss the problems with your classmates — just bear in mind that your goal should be to develop your own understanding, not simply to copy down an answer. You're also welcome to check with Dr Bill or Melina to see whether your approach to a given problem is sound.

The real exam will be completed in person, at a chalkboard or whiteboard, in groups of 2 or 3 students. (If you prefer to present your solutions on your own, in a group of 1, we can arrange that, but I think you will be more comfortable with the camaraderie of a fellow student or two.) [If you asked for accommodated exams, we should discuss how to make this work.]

We will solve the same problems at the board, with no notes, no books, no computers, no electronic gadgets, but if you need help remembering an equation or some other detail, you can ask me and your fellow students for help. We will also cooperate to make sure we agree on each part of a problem before going on to the next part.

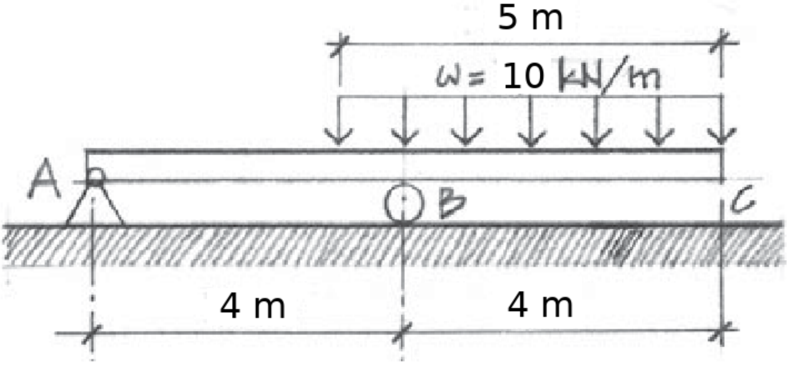
We will take turns (choosing at random) leading the discussion of the problems, with one person at the board at a time, but I and your fellow students can offer input if you like. For a longer problem, one person will lead for part (a), then another person will lead for part (b), and so on. For a short problem, one person can lead while the rest of us help to avoid mistakes.

Each person will be graded individually, based on your demonstrating to me that you know how to solve the problems and understand the physics behind each problem. The exam is not a huge part of your grade, just 25%, and many of you have accumulated worksheet and reading scores above 100%. There is also my standard option to earn up to a maximum of 5% extra-credit via supplementary readings or a variety of computer exercises that some students in past years have completed. So this is not a high-stakes exam. My hope is that this format, while unusual, will provide more learning and less stress than a traditional written final exam, and I hope it will be a good fit for the cooperative problem-solving format we have used throughout the semester.

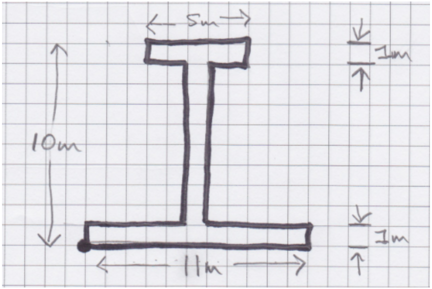
We will stop when we've finished all of the problems, or when two hours have elapsed, whichever comes first. Working slowly while showing good understanding is a valid approach, so you don't need to feel pressure to work quickly.

Groups will be determined by who signs up for which time slots (maximum of 3 people per time slot), which may or may not coincide with your usual workgroups. We will meet either in my office (DRL 1W15) or in a nearby DRL classroom.

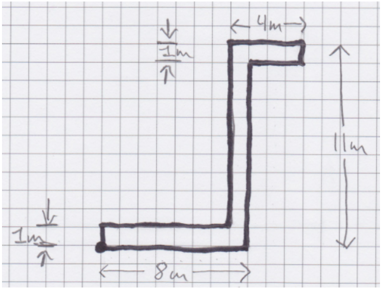
1. Solve for the support "reaction" forces at A and B (i.e. the forces exerted by the supports at A and B on the beam) in the figure below. To do this, you will need to convert the distributed load into an equivalent concentrated load. (A very similar problem was XC problem 4 on ws23. I edited the numerical values for today.) Your solution should include a redrawn EFBD for the beam, showing the equivalent point load and the support forces at points A and B.



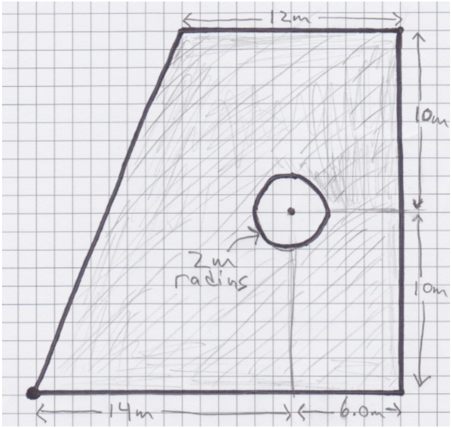
2. Find the centroid of the enclosed area shown below. Take the bottom-left corner of the enclosed area (where the large dot is drawn) to be the origin $(0, 0)$ of the coordinate system. The side of each square on the graph paper represents $1.0\,\mathrm{m}$.



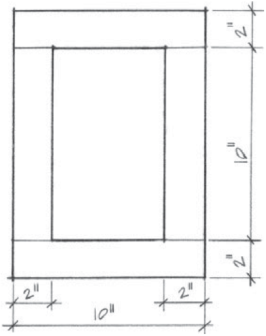
3. Find the centroid of the enclosed area shown below. Take the bottom-left corner of the enclosed area (where the large dot is drawn) to be the origin $(0,0)$ of the coordinate system. The side of each square on the graph paper represents $1.0\,\mathrm{m}$.



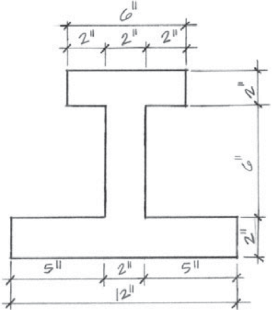
4. Find the centroid of the enclosed shaded area in the figure below. A circle of radius 2.0 m is missing from the shaded area. Take the origin of the coordinate system to be the center of the circle, which the figure indicates with a dot. Hint: treat the circle as "negative area" when you do the weighted averages to find the centroid. This problem shows a mathematical analogue to the aesthetic idea of "negative space" in design!



5. Determine the second moment of area $I_x = \int y^2 \, \mathrm{d}A$ for the box-beam cross-section shown below. Take $y = 0$ to lie at the centroid of the cross-section. Take as given the result $I_x = bh^3/12$ for a rectangle of width b and height h whose centroid is at $y = 0$. The key result you need is $I_x = \sum I_{xc} + \sum A d_y^2$, where each sum is over the constituent simple shapes that compose the final shape. For each simple shape, I_{xc} is that shape's own I_x value about its own centroid, A is that shape's area, and d_y is the vertical displacement of that shape's centroid from $y = 0$. (Note that taking 4th root of your answer for I_x is one way to check whether it is of a plausible magnitude.)



6. (Save this problem for last. If time is short, we'll make it optional/XC.) First compute the centroid $\overline{x}$ and $\overline{y}$ for the cross-section shown below. (It's OK to say that $\overline{x}$ is obvious from symmetry.) Then determine the second moment of area $I_x = \int y^2\, \mathrm{d}A$, taking $x = 0$ and $y = 0$ to lie at your calculated centroid. The dimensions are given in inches, so I_x should have units in^4. Your solution should include a redrawn figure that shows your calculated centroid. The method is the same as in the previous problem, except that here you need to start by finding the centroid $\overline{y}$. Because of the lack of vertical symmetry, even the middle shape will have a non-zero d_y value in this problem.



XC7*. (O/K ch5.) A 10 foot $\times$ 20 foot hotel marquee (shown below) hangs from two rods inclined at an angle of 30°. The dead load and snow load on the marquee add up to 110 pounds per square foot. Design the two rods out of A-36 steel that has an allowable tensile stress $F_t = 21000\,\mathrm{psi}$ (psi = pounds per square inch). To solve this problem, you first need to convert the distributed load into an equivalent point load (in pounds), then analyze the two-dimensional problem shown in the section view. By symmetry, each tie rod supports half of the total load. Then you need to use static equilibrium to find the tension (measured in pounds) in one tie rod. Finally, use the allowable tensile stress to find the required diameter (in inches) of a tie rod. Be careful with factors of 2 in diameter vs. radius, with inches vs. feet, and that the total load is shared between two tie rods. This problem may leave you wondering why the US has not yet switched to the metric system.