Your Name: ______________________________

Teammates: ____

Physics 8, Fall 2023, Worksheet #24.

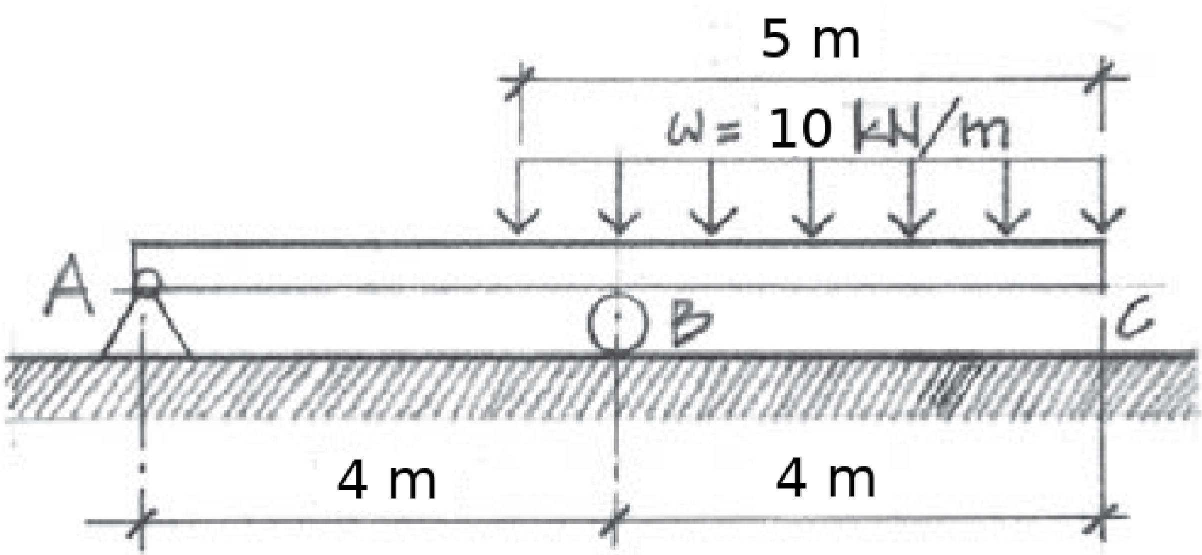
`http://positron.hep.upenn.edu/p8/files/ws24.pdf`

Upload PDF (smartphone scan or tablet edit) to Canvas shortly after class on Mon, Nov 27, 2023.

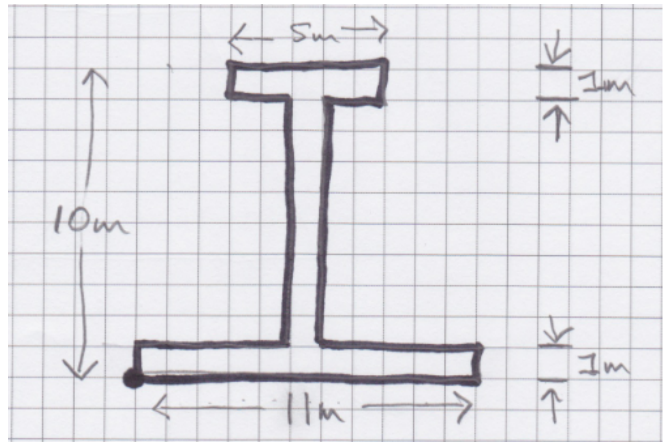
Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Discuss each problem with your teammates, then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result. Do not hesitate to ask for help from other students or from the instructors — but don't just copy down other people's results!

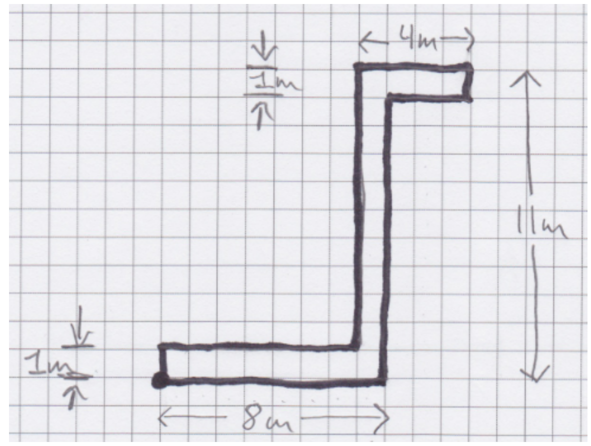
1. Solve for the support "reaction" forces at A and B (i.e. the forces exerted by the supports at A and B on the beam) in the figure below. To do this, you will need to convert the distributed load into an equivalent concentrated load. (This is very similar to problem 4 on ws23. I edited the numerical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



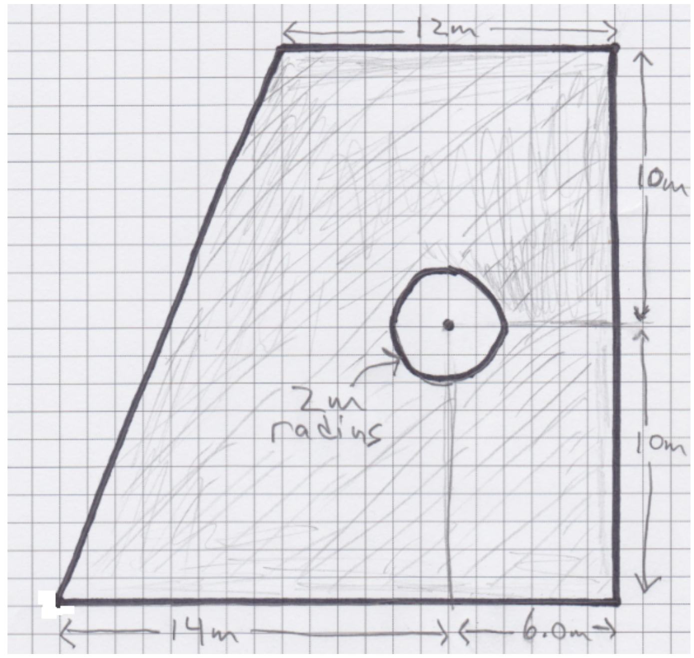
2. Find the centroid of the enclosed area shown below. Take the bottom-left corner of the enclosed area (where the large dot is drawn) to be the origin $(0, 0)$ of the coordinate system. The side of each square on the graph paper represents 1.0 m.



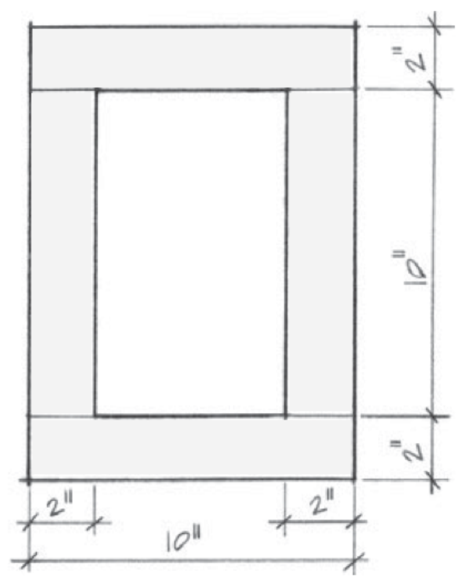
3. Find the centroid of the enclosed area shown below. Take the bottom-left corner of the enclosed area (where the large dot is drawn) to be the origin $(0, 0)$ of the coordinate system. The side of each square on the graph paper represents $1.0\,\mathrm{m}$.



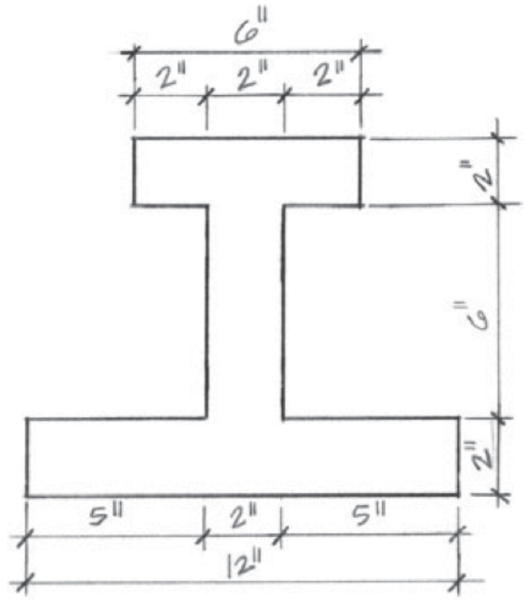
4. Find the centroid of the enclosed shaded area in the figure below. A circle of radius 2.0 m is missing from the shaded area. Take the origin of the coordinate system to be the center of the circle, which the figure indicates with a dot. Hint: treat the circle as "negative area" when you do the weighted 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. The dimensions are given in inches, so I_x should have units in^4. 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 $y = 0$. There are two ways to solve this problem. The conventional approach is to use the method of Onouye/Kane §6.3, i.e. the parallel-axis theorem, to find I_x for the composite shape. 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. (In this example, the sum is over the 4 rectangular shapes that compose the box-beam cross-section.) 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.) But there is a much quicker and more clever way! Notice that the box-beam shape can be formed by subtracting a small rectangle from a larger concentric rectangle! The clever method turns the solution of this problem into a one-liner, using the "negative area" idea.



6. 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 × 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.