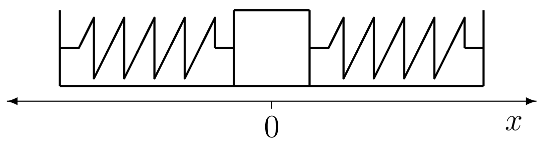
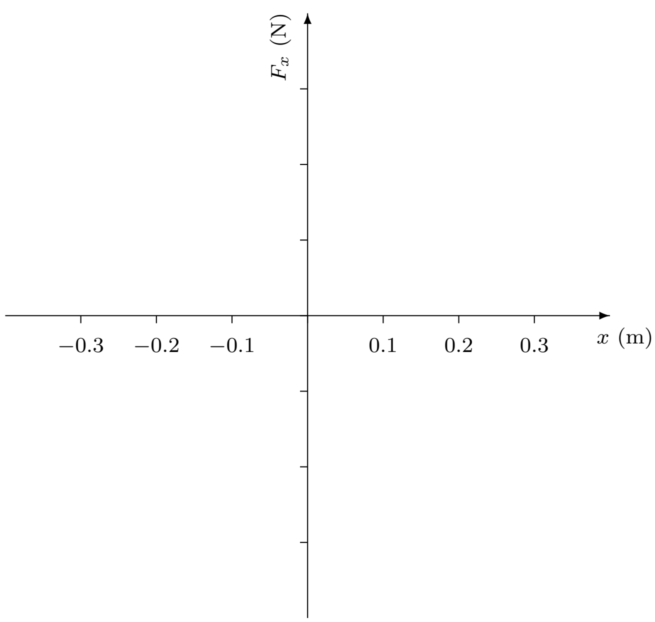
Exam 1; Phys 186 Name ________________

Note: You can ask me for help; for example, have me check if an answer is correct. Talk to me: you'll learn some physics during the exam, and that's the point of the course.

1. (30 points) You have a 0.32 kg object attached to two identical springs, each with spring constant 10.0 N/m, at each end as shown in the diagram. The mass oscillates back and forth horizontally on a frictionless surface.

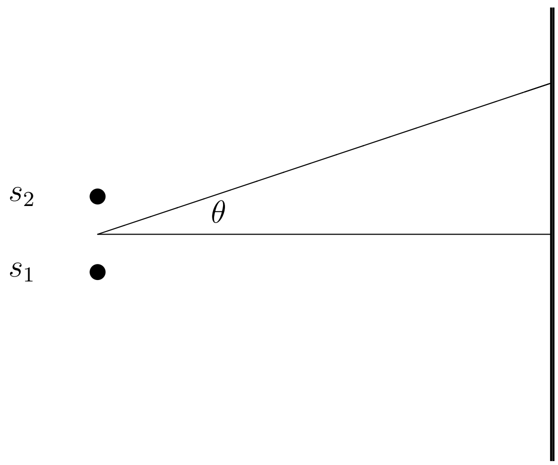


(a) Using the axes given, draw a graph of the total force on the mass F_x vs. the displacement from equilibrium x. Take care to indicate the force direction with appropriately positive or negative quantities. Write in the appropriate numbers on the tick marks on the F_x axis on your graph.

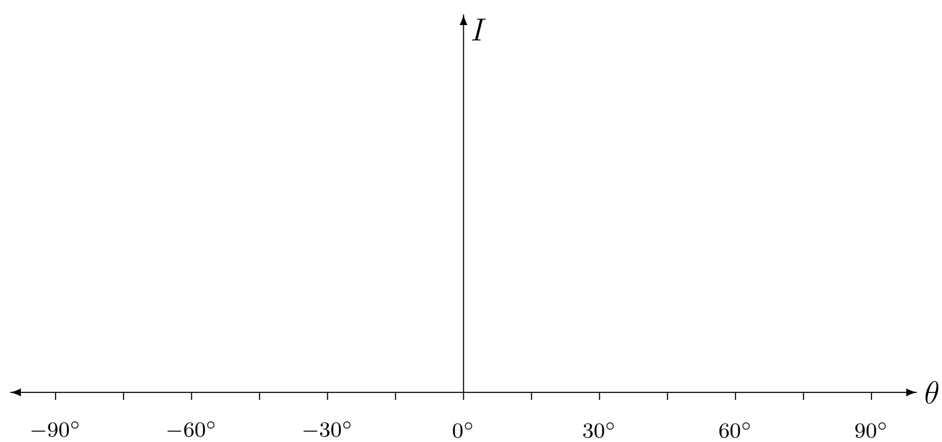


(b) The oscillations of a single spring have an angular frequency $\omega = \sqrt{k/m}$. What is the angular frequency for the oscillations of this double spring setup? Explain.

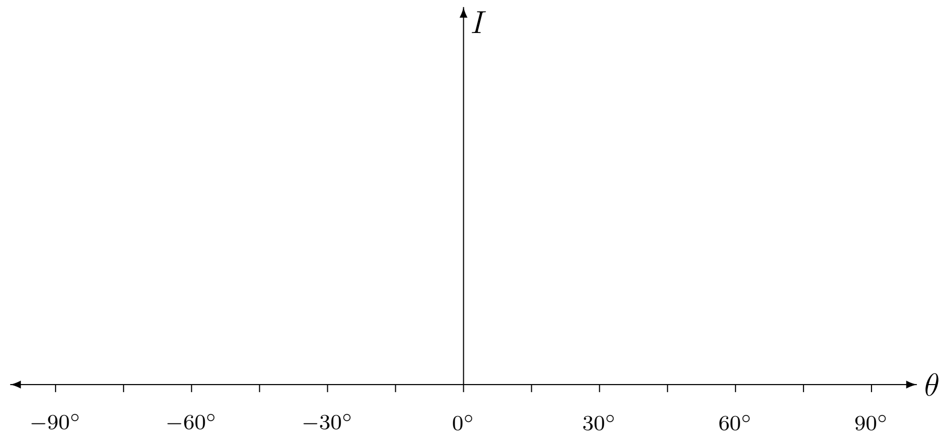
2. (40 points) You have two sources of waves with identical frequencies, amplitudes, and wavelengths, s_1 and s_2, separated by a distance of 2.2 wavelengths: $d = 2.2\lambda$. To the right there is a screen that records intensity at angles θ. The waves and the setup are entirely two-dimensional, so don't worry about depth.



(a) s_1 and s_2 are completely in phase: they emit peaks and troughs of waves simultaneously. Plot a rough intensity versus angle graph. Be careful about whether your minima are exactly zero are not. Calculate and indicate the angles at which the *maxima* occur.



(b) s_1 and s_2 are completely out of phase: when one emits a peak the other emits a trough. Plot a rough intensity versus angle graph. Be careful about whether your minima are exactly zero are not. Indicate the angles at which the *minima* occur.

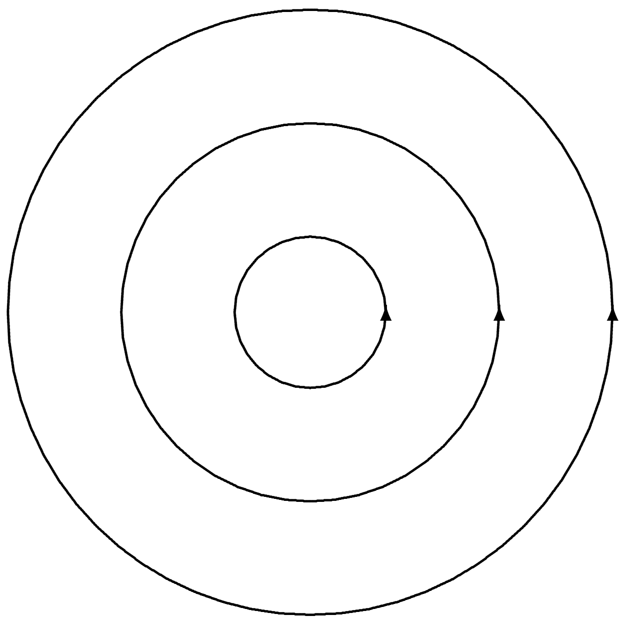


3. (30 points) Say you want to build an instrument to separate visible light from a light source into its colors. You decide to use a diffraction grating. Since this is supposed to be a scientific instrument, you want to be able to project the pattern of colors onto a screen, and measure the angles corresponding to each color. What range (lowest to highest) of d values (distance between adjacent slits) on your diffraction grating would give you a useful instrument? You'll need to make some reasonable assumptions and estimations, using, for example, your experience in lab settings or playing with a grating in the classroom demonstrations. State the details of your reasoning clearly.

4. (20 points) You have sound waves in air, with a frequency of f and speed of v_a, incident on a solid surface. The angle between the normal to the interface and the direction of wave propagation in air is θ_a. The speed of sound in the solid is v_s. Find an equation for θ_s, the angle the sound transmitted into the solid makes between the normal to the interface and its new direction of propagation. Explain your reasoning. (*Hint:* You know the equation you'd use for light waves. What is the reasoning that leads to that equation, and how could you then get an equivalent for sound?)

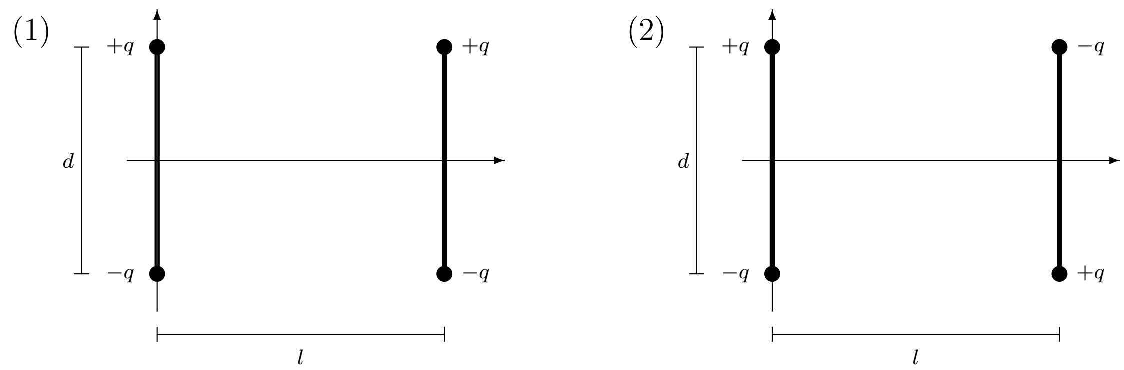
5. (30 points) A fellow student tells you they also did the equipotential line mapping lab, and they worked with a charge configuration that produced concentric *electric field lines* as shown. A physics major overhears your conversation, and tells you that such an electric field is impossible if all you had was a stationary charge distribution, and that's all you had in that lab. Unfortunately, she walks off before explaining why.

(a) Start drawing the equipotential lines that might correspond to this electric field. Identify the problems you run into that show that these electric field lines are impossible.



(b) We discussed the rules for electric field lines, such as "the lines can't intersect except where there is a charge"; "electric field lines are perpendicular to equipotential lines" and so forth. What rule would you add to capture the impossibility of an electric field as above?

6. (50 points) You have two dipoles side by side. In case (1), they are parallel, in case (2), antiparallel as shown. The magnitude of each charge is q, the separation between the charges in each dipole is d, and the distance between the centers of the two dipoles is l.



(a) Calculate the total force on the dipole on the right due to the dipole on the left, for cases (1) and (2). What do you conclude about dipoles attracting or repelling one another, depending on how they are aligned?

(b) Calculate the total electric energy of the dipole on the right, for cases (1) and (2). Note that the dipoles are already assembled, so you don't need to include *internal* energies due to each charges' interaction with the other charge on the same dipole.

(c) Which do you think is the more stable configuration, (1) or (2)? Will neighboring electrical dipoles tend to line up parallel or antiparallel?