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 learning physics is the point of the course.

1. (30 points) We discussed why, if you put up two identical speakers producing identical tones with the same wavelength in an ordinary classroom, you would not observe an interference pattern. But when I gave you diffraction gratings and laser pointers, you saw the interference pattern on your desks even when the lights were on. (They were easier to see with the lights off, but that wasn't crucial.) Explain.

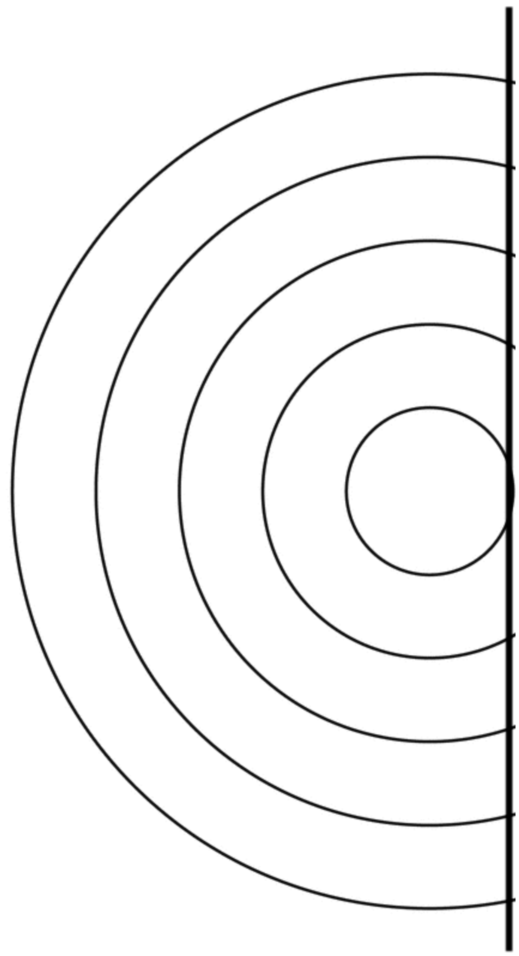
2. (30 points) You're given a spring, a known mass m_0, and an unknown mass m_1. The only measuring device you have is a stopwatch. Describe an experiment you would design in order to determine m_1. Provide an equation that expresses m_1 in terms of m_0 and quantities you can measure with your stopwatch.

3. (30 points) Say you want to redesign the double-slit experiment with the microwave apparatus. With 3.0 cm wavelength microwaves and a distance between slit centers of $d = 5.5$ cm, you could see the $m = 0, \pm 1$ peaks with your detector, but the $m = \pm 2$ and higher peaks did not exist. Now you want to adjust d to show you the $m = 0, \pm 1, \pm 2$ peaks but not $m = \pm 3$ and higher. Therefore d should be a value $d_{\text{min}} \leq d < d_{\text{max}}$, where d_{min} just barely shows the $m = 2$ peak at the largest angle possible, and d_{max} just barely shows the $m = 3$ peak at the largest angle possible. Find d_{min} and d_{max}.

Hint: What *is* the largest angle possible?

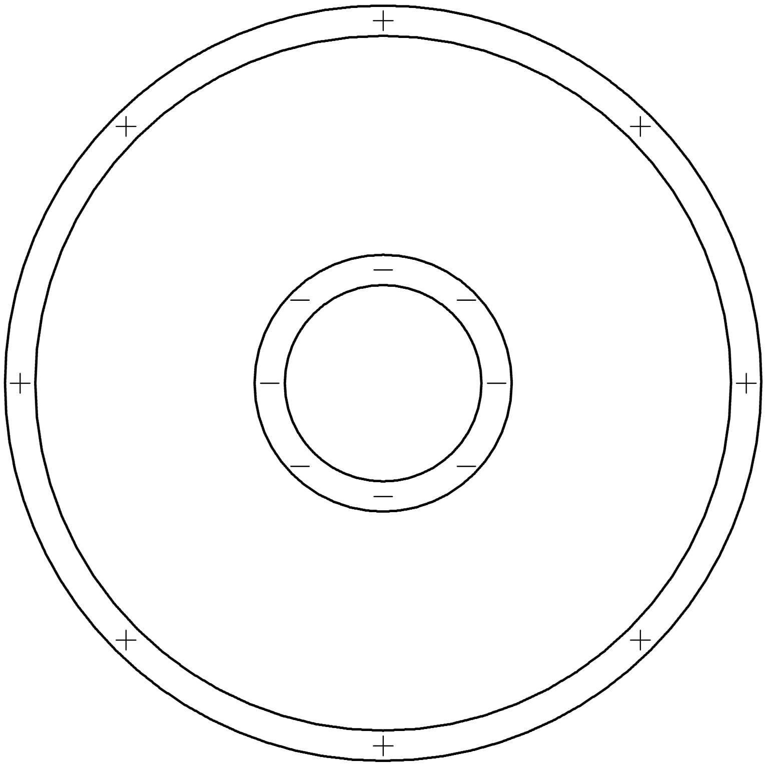
4. (30 points) You have water waves on the surface of a lake, with wavefronts that spread as concentric circles from a central source, traveling at a constant speed v_{deep}. The straight line indicates a boundary where the lake bottom suddenly steps up, so the waves enter a shallow region where $v_{\text{shallow}} < v_{\text{deep}}$.

(a) Draw how the wavefronts will look in the shallow part of the lake.



(b) Briefly explain your reasoning.

5. (30 points) You have a cylindrical capacitor: two concentric metal rings with equal and opposite charges. The outer ring is at 4.0 V, the inner ring is at 0.0 V. Draw a qualitative map of the 0 V, 1 V, 2 V, 3 V, and 4V equipotential lines. Be careful about the line spacings: are the spacings constant, or do they increase or decrease as you go from high voltage to lower voltage? Then draw the electric field lines between the two rings.



Also: what is the voltage and electric field inside the inner ring?

6. (50 points) Let's do a full dipole calculation: find the electric field $\vec{E}$ and voltage V anywhere on the xy-plane, not just on the x-axis. We have a $+q$ charge at $x = 0$ and $y = +d$, and a $-q$ charge at $x = 0$ and $y = -d$.

(a) Draw a picture, with x and y axes, and charges in place. Then pick a point with coordinates $x > 0$ and $y > d$, and draw lines indicating r_1, the distance to the $+q$ charge, and r_2, the distance to the $-q$ charge. Next, identify the right triangles you will use to get trigonometric functions of the angles θ_1 and θ_2 (*Hint:* One side of the triangles will have length x). Finally, draw arrows indicating $\vec{E}_1$ and $\vec{E}_2$.

(b) A friend gives you the following calculation, which is full of errors. Identify and correct the errors, and produce the correct result for $\vec{E}$.

$$E_1 = \frac{kq}{r_1}, \quad E_2 = -\frac{kq}{r_2} \quad \text{with} \quad r_1 = x^2 + (y+d)^2, \quad r_2 = x^2 + y^2$$

$$E_{1x} = -E_1 \tan\theta_1 = -\frac{kq}{r_1}\frac{y-d}{x} = -\frac{kq(y-d)}{x[x^2+(y+d)^2]}$$

$$E_{1y} = +E_1 \sin\theta_1 = +\frac{kq}{r_1}\frac{y-d}{r_1} = -\frac{kq(y-d)}{[x^2+(y+d)^2]^2}$$

$$E_{2x} = -E_2 \tan\theta_2 = -\frac{kq}{r_2}\frac{y+d}{x} = -\frac{kq(y+d)}{x(x^2+y^2)}$$

$$E_{2y} = +E_2 \sin\theta_2 = +\frac{kq}{r_2}\frac{y+d}{r_2} = -\frac{kq(y+d)}{(x^2+y+^2)^2}$$

$$\vec{E} = E_{1x} + E_{1y} + E_{2x} + E_{2y} = \text{(add all the above)}$$

Now give the correct calculation for $\vec{E}$:

(c) Calculate the total voltage V at the same point (x, y).