1 (26 points) Laser light strikes a single slit, producing a characteristic intensity pattern. The intensity at the pattern's center is I_0, but you are observing at a point to the side, point P, where light from one edge of the slit and light from the other edge are out of phase by $5\pi/3$ radians. (a) What is the intensity here? (b) Phasors help us understand intensity variation. Imagine breaking the light emerging from the slit into 5 phasors/pieces, representing light leaving from 5 regions within it. For these phasors to produce the same intensity at the pattern's center as light from the whole slit, each would have to have an amplitude one-fifth the amplitude produced at the center by the light from the whole slit. And if the phase difference between light leaving one edge of the slit and the other were β, then each phasor would be out of phase by $\beta/5$ with the adjacent one. Accepting these assumptions, sketch a phasor diagram showing how the 5 phasors would add at the point P of part (a), and from your diagram determine what intensity would result at that point. (c) Five regions is obviously not infinity, but is your intensity in part (b) reasonably close to the exact value of part (a)?

2 (18 points) Light from a gas sample strikes a diffraction grating of 6250 slits per centimeter. One of the wavelengths emitted by the gas is 447.0nm. (a) When viewing the second-order light, another wavelength appears at an angle only 0.10° smaller than that for the 447.0nm. What is this other wavelength? (b) How many orders can be observed of the 447.0nm light?

3 (23 points) Using a combination of two lenses you study a little animal, only 5.0cm tall, from a safe distance (so you don't you scare it). The animal/object is 3.00m to the left of the objective lens, a converging lens of 1.00m focal length. The eyepiece, a diverging lens of –0.40m focal length, is 1.00m to the right of the objective lens. Determine the location and height of the final image.

4 (18 points) An insulated water jug contains a mass m of water, whose specific heat is c_w. The insulation has thermal conductivity k, is of thickness x on all sides, and its total surface area (separating the water inside from the hot outside environment) is A. If the water is initially at 0°C and the outside temperature is kept at a constant 30°, how long will it take for the water to warm to 15°C? Your answer should be in terms of the given symbols. Assume that the water's warming is slow, so that at a given instant in time, all the water's temperature is essentially the same, and the heat flow rate is the same throughout the insulation. Ignore any heat needed to alter the temperature of the *insulation*. (Note: Though the details are different, this problem involves steps and techniques that should be familiar. Does the heat flow vary with time?) An approximate answer will earn some partial credit.

5 (15 points) From Physics 9A we know that escape speed is $\sqrt{2GM/R}$, where M and R are a planet's mass and radius, and $G = 6.67\times10^{-11}\,\mathrm{N\cdot m^2/kg^2}$. A newly discovered planet has a mass of 6.0×10^{20}kg, a radius of 300km, and a typical surface temperature of 200K. Is it likely to have an atmosphere containing oxygen? Justify your answer. The mass of an oxygen molecule is 5.3×10^{-26}kg.