

Physics 31b Final (300 pts)

1. (a) Calculate the wavelength of an electron once it has been accelerated through a potential of 110 V and compare that to X-rays. Assume the speed is nonrelativistic.  
  
(b) State and explain (I) Schrödinger Wave Equation (II) Pauli Exclusion Principle
  
2. (a) The helium-neon laser puts out a bright red beam at a wavelength of 632.8 nm. Please determine the difference in energy between the two states defining the transition.  
  
(b) A cube of rough steel 10 cm on a side is heated in a furnace to a temperature of 400 °C. Given that its total emissivity is 0.97, determine the rate at which it radiates energy from each face.
  
3. (a) A diffraction grating produces a second-order spectrum of yellow light ( $\lambda = 550$  nm) at 25 °C. Determine the spacing between lines.  
  
(b) A Michelson interferometer is illuminated with monochromatic light. One of its mirrors is then moved  $2.53 \times 10^{-5}$  m, and it is observed that 92 fringe-pairs, bright and dark, pass by in the process. Determine the wavelength of the incident beam.
  
4. (a) The image of a child reflects off a wet city street. At what angle should the reflection be viewed if it is to be seen in totally polarized, linear light? Give your answer to three significant figures.  
  
(b) A glass microscope lens with an index of 1.55 is to be coated with a magnesium fluoride ( $n = 1.38$ ) film to increase the transmission of normally incident yellow light ( $\lambda_0 = 550$  nm). What minimum thickness should be deposited on the lens?
  
5. (a) If an object 200 cm from the vertex of a spherical concave mirror is imaged 400 cm in front of the mirror, what is the latter's focal length?  
  
(b) A rather expensive well-corrected (for aberrations) lens consists of three simple lenses of focal length +10 cm, -20 cm, and +5.0 cm all glued together. What is the combined focal length? Can it form real images?

6. (a) A photographer wishes to take a picture of his pet chicken Fred, who happens to have a fine face 5.0 cm high. While standing 2.0 m away, he selects a lens that will fill the film (24 mm top-to-bottom) with Fred's poultry physiognomy. What lens should be used?
- (b) Suppose we wish to make a microscope (which can be used with a relaxed eye) out of two positive lenses both of focal length 25 mm. Assuming the object is positioned 27 mm from the objective, (a) how far apart should the lenses be and (b) what magnification can we expect?
7. (a) We wish to place an object 45 cm in front of a lens and have its image appear on a screen 90 cm behind the lens. What must be the focal length of the appropriate positive lens?
- (b) Using a block of a transparent, unknown material, it is found that a beam of light inside the material is totally internally reflected at the air-block interface at an angle of  $48.0^\circ$ . What is its index of refraction?
8. If the plate has a thickness  $\tau$ , show that the emerging beam is laterally displaced by a perpendicular distance  $d$  from the incident beam where
- $$d = \frac{\tau \sin(\theta_{i1} - \theta_{t1})}{\cos \theta_{t1}}$$
9. (a) An L-C-R series circuit contains a 500- $\Omega$  resistor, a 5.0-H choke coil, and a capacitor. What value of capacitance will cause the circuit to resonate at 1000 Hz what can you say about the practicality of your result?
- (b) A series circuit contains a 240- $\Omega$  resistor, a 3.80  $\mu F$  capacitor, and a 550-mh inductor. Its placed across the terminals of an ac generator set to 100 Hz, if an ammeter in the circuit reads 250 mA effective, what is the maximum voltage of the generator?