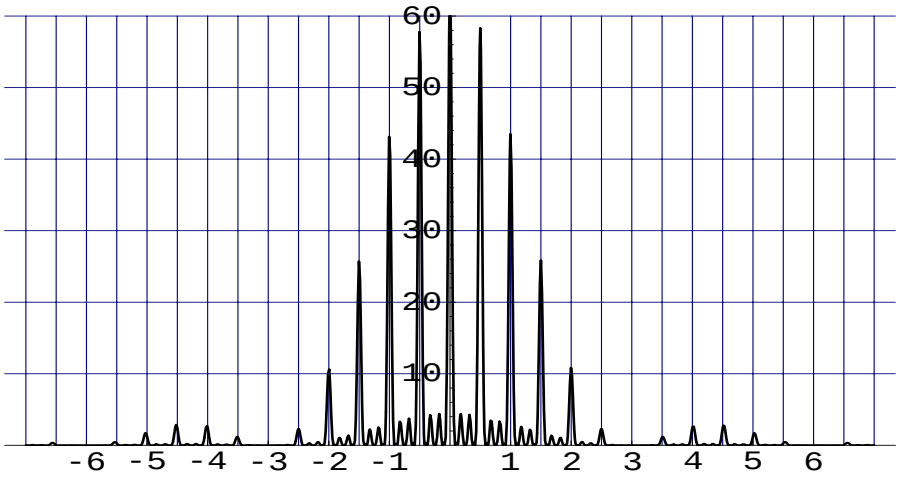
Name _____ **Student ID** _____ **Score**_____

last *first*

Part I. [24 points] The intensity graph below was produced in an experiment in which monochromatic light of wavelength $\lambda = 632.8$ nm was incident on N evenly-spaced slits, each of which has width a. The distance between the centers of adjacent slits is d_{adj}. The x-axis is in degrees.



1. [4 points] What is the number of slits (N)?

   A. 2
   B. 3
   C. 4
   D. 10
   E. none of the above

2. [4 points] What is the width of each individual slit (a)?

   A. $a = 6053$ nm
   B. $a = 12091$ nm
   C. $a = 36259$ nm
   D. $a = 72514$ nm
   E. $a = 217541$ nm

3. [4 points] What is the distance between the centers of adjacent slits (d_{adj})?

   A. $d_{adj} = 6053$ nm
   B. $d_{adj} = 12091$ nm
   C. $d_{adj} = 36259$ nm
   D. $d_{adj} = 72514$ nm
   E. $d_{adj} = 217541$ nm

4. [4 points] How would the maximum intensity if only one slit were open (I_{max}, 1) compare to the maximum intensity in the original experiment (I_{max}, N)?

   A. $I_{max,\,1} = I_{max,\,N} / N$
   B. $I_{max,\,1} = I_{max,\,N} / N^2$
   C. $I_{max,\,1} = I_{max,\,N} / N^{1/2}$
   D. None of the above

5. [4 points] If the spacing between adjacent slits (d_{adj}) were decreased, what would happen to the maximum intensity?

   A. The maximum intensity would *increase.*
   B. The maximum intensity would *decrease*.
   C. The maximum intensity would remain the *same.*
   D. Not enough information is given.

6. [4 points] If the width of each slit (a) were decreased, what would happen to the maximum intensity?

   A. The maximum intensity would increase.
   B. The maximum intensity would decrease.
   C. The maximum intensity would remain the same.
   D. Not enough information is given.

Name _____ **Student ID** _____ **Score**_____

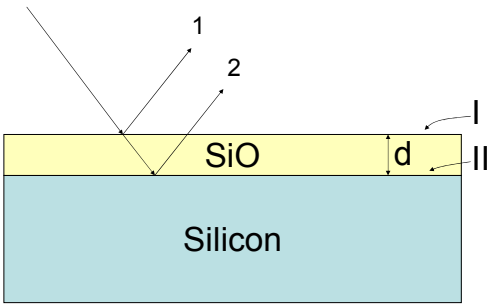
last *first*

Part II. [15 points] Assume for the thin film problems below that the light waves have near normal incidence.

7. [4 points] The skin coating of a stealth aircraft is designed such that radar waves are not reflected. For this quick calculation, consider radar waves with a frequency of 1.5×10^{10} Hz. Ignore any phase changes that occur at the coating surfaces and also assume the speed of the radar waves is the same inside the coating as it is in air. Determine the minimum thickness of the coating such that the radar waves are not reflected.

   A. 0.5 cm
   B. 1.0 cm
   C. 2.0 cm
   D. 3.0 cm
   E. 4.0 cm

For questions 2 to 6, consider the diagram of the solar cell shown. The cell, made of Si (n=3.5) is coated with a thin film of Silicon-Oxide (SiO, n=1.45).



8. [3 points] At which surface(s) does a reflected light wave experience an 180^o phase change for light with λ=550 nm?

   A. I
   B. II
   C. I and II
   D. None

9. [3 points] At which surface(s) does a reflected light wave experience an 180^o phase change for light with λ=440 nm?

   A. I
   B. II
   C. I and II
   D. None

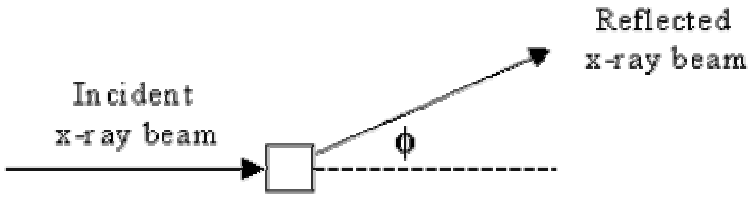
10. [5 points] Determine the minimum thickness of the SiO coating so that light with a wave length of λ=550 nm will not be reflected.

    A. 94.8 nm
    B. 189.6 nm
    C. 137.5 nm
    D. 275.0 nm
    E. 550.0 nm

Name _____**Student ID** _____ **Score**_____

last *first*

Part III. [16 points] A beam of x-rays with a wavelength of 0.064 nm is incident on a crystal. The angle of deviation for the second order reflected beam is $\phi_2 = 59°$. The experimental setup is shown schematically in the figure below.



11. [4 points] Find the spacing between the atomic planes in the crystal responsible for the second order reflection

    A. 0.068 nm
    B. 0.075 nm
    C. 0.13 nm
    D. 0.10 nm
    E. None of the above

12. [4 points] Find the angle of deviation, ϕ_1, for the first order reflected beam.

    A. 2.82×10^{-8} degrees
    B. 14.3 degrees
    C. 25.4 degrees
    D. 28.5 degrees
    E. 50.8 degrees

13. [4 points] Find the number of Bragg reflections that can occur for this interplane spacing and x-ray wavelength.

    A. 1
    B. 2
    C. 3
    D. 4
    E. 5

14. [4 points] Find the longest possible x-ray wavelength that will produce a Bragg reflection.

    A. 0.14 nm
    B. 0.15 nm
    C. 0.20 nm
    D. 0.26 nm
    E. None of the Above

Name _____**Student ID** _____ **Score**_____

last *first*

Part IV. [25 Points] A star is 90 light-years away. An observer on earth measures the space craft to be traveling at 0.87c. A light year is the distance light travels in one year. $c=3x10^8$ m/s. Most years have 31536000 seconds in them (not leap years).

15. [5 Points] According to the observer on earth, how long does it take the spacecraft to get star?

16. [5 Points] According to the occupants on the space craft, how far will they have traveled?

17. [5 Points] According to the occupants on the space craft, how long does it take them to get to the star?

18. [5 Points] Calculate the velocity using the time and length observed by the occupants of the craft (and calculated above). Will they measure the same speed as the earth observers measured? Explain.

19. [5 Points] A mutinous crew member fires a bullet at 0.75c on the spaceship. It is fired in the same direction as the spaceship is moving. Will an observer on earth who measure's the bullet's velocity see it going at 1.62c? Explain.