PHYSICS 262 Fall 2011 Exam 2 (problems 1-4)	SIGNATURE:______________________. Banner ID:_________________________.

INSTRUCTIONS:
This is a take-home exam that is due at the beginning of class, 12PM, Monday October 31. You may use any source of information except another person. Please fill in your Banner ID and clearly indicate your answers Please sign this exam above, signifying you followed the UNM Honor Code, and return this exam with neatly filled out answer sheets attached Monday at noon.

1. (10 pts) One of the early thought experiments Einstein considered was attempting to understand what he would see if a mirror was placed in front of him while he and the mirror were traveling at a speed close to that of light.
Since you've studied special relativity, you can now confidently give Einstein an answer to his question: What will Einstein see in a mirror if he and the mirror are in an IRF that is traveling at close to the speed of light?
Ans: The speed of light is the same in all frames of reference. Therefore Einstein will see himself reversed front to back, just as he would in any mirror in any IRF.

2. (40 pts) Suppose intelligent life is discovered on a planet orbiting a star 5 light years away from the sun. After many years of communication and planning, an exchange program is arranged thusly:
Interstellar spaceships will be launched simultaneously from each planet toward the other. Both spaceships will travel at v/c=0.6 towards the other planet. To avoid an accidental head on collision, each spaceship will flash an omnidirectional light beacon at rate of one flash every 10^{-6} years (about once every 30 seconds) as measured in the spaceship's IRF. The beacons will be turned on immediately after launch.

(10) Neatly draw the Minkowski Diagram for this situation. Label all of the key events and axes.
See diagram at the end.
(6) In the IRF of the spaceships, how long does the trip take?
See point "B" on the Minkowski Diagram. Proper time. Elapsed time on the spaceship is less than the elapsed time on earth— 25/3 years on Earth appears to be $25/(3\gamma)= 20/3$ years on the spaceship.
(6) the IRF of the spaceships, what is distance between the planets?
See point "C" on the Minkowski Diagram. Length Contraction. 5 lys in the Earth's IRF appears to be $5/\gamma=4$ lys in the spaceship IRF..
(6) How long after the simultaneous launch of the spaceships does the first light beacon flash from the alien spaceship arrive at earth?
See point "D" on the Minkowski Diagram. Light takes 5 years to travel 5 ly.
(6) How long after launch does the earth's spaceship see the first flash from the alien spaceship?
See point "E" on the Minkowski Diagram. The intersection of the ct=v/c x and ct = -x+5 lines occurs at (0, 5/2) in the spaceship IRF. Therefore the Earth's spaceship sees the flash from the launch of the alien spaceship 2.5 years into it's journey.
(6) What is the period of the light flashes from the alien spaceship as observed on earth?

No flashes arrive from the alien spaceship for the first five years. Then all of the flashes emitted by the alien ship are compressed into the remaining time. This makes the period one half as long as in the spaceship IRF or 1 flash every 0.5×10^{-6} years arriving at Earth.
What is the period of light flashes from the earth's spaceship as observed on earth? These flashes get spaced out in time when they reach Earth. The Earth sees 1 flash every 2×10^{-6} years from the earth's spaceship.

3. (25 pts) In my collection of computer discs are several that I cannot tell if they are CD, regular DVD or BluRay DVD discs. It was suggested that I can use my laser pointer to determine which is which. Since the discs consist of closely spaced metallized grooves, a multislit diffraction pattern characteristic of the groove spacing should be created. The amount of information stored increases going from CDs, to DVDs to BluRay DVDs and hence I expect the groove spacing is to be largest on CD and smallest on the BluRay with the regular DVD somewhere between.

A) (10) When the audio compact disc is illuminated by my laser pointer, diffracted beams are created at angles $\theta_0=0°$ (reflected straight backward) and θ_1 and θ_2. I know the spacing between tracks on a CD is 1.6 μm. If θ_1 is measured to be 19.5° = 0.34 radians, what is the wavelength of my laser pointer? What is θ_2?
Ans: using $kd\sin(\theta_0 = 0°) = 0 \cdot 2\pi$, $kd\sin(\theta_1 = 19.5°) = 1 \cdot 2\pi$, $kd\sin(\theta_2) = 2 \cdot 2\pi$, we find the wavelength from $k=2\pi/\lambda$. λ=534 nm. This means that θ_2=41.9°.

B) (10) A DVD disc replaces the CD and θ_1 is measured to be 46.0° = 0.80 radians. What is the spacing between tracks on a DVD? What is θ_2?
Ans: using $kd\sin(\theta_0 = 0°) = 0 \cdot 2\pi$, $kd\sin(\theta_1 = 46.0°) = 1 \cdot 2\pi$, $kd\sin(\theta_2) = 2 \cdot 2\pi$, we find the spacing from $d=\lambda/\sin(\theta_1)$=742 nm. This implies that $\sin(\theta_2) = 2\lambda/d$=1.44. This cannot happen therefore θ_2.does not exist (actually it does as an "evanescent mode" which will be an important physical concept when we study quantum mechanical tunneling).
C) (5) A BluRay disc has a track spacing of 0.32 μm. What happens to θ_1 and θ_2?
Ans: Neither θ_2 or θ_2 exist - they are both "evanescent modes." This means that the laser pointer really isn't a good tool for finding spacings when they are about the same size as the wavelength of the pointer.

4. (25 pts) Current smartphone cameras typically have the following specifications: f/# of 2.4, focal length of 4.28 mm and an 8 megapixel sensor. You might be able to Google numbers for some of the following, but please show the equations that are used to get these results.

A) (10) What is the smallest angular difference the camera can detect using the Rayleigh Criterion?
An f/# of 2.4 and a focal length of 4.28 mm gives (taking f/D=f/#) the diameter of the lens D to be 1.78 mm. For the Rayleigh Criteria, the minimum angle resolved by a lens of 1.78 mm diameter is $\theta=1.22\lambda/D = 3.43 \times 10^{-4}$ radians assuming λ=0.500 μm = 500 nm.
B) (10) What is the optimal spacing between the pixels in the focal plane given this resolution?
3.43×10^{-4} radians times the focal length gives the distance on the focal plane of about 1.47 μm. This is the optimal pixel spacing.

C) (5) If the aspect (length to width) ratio of the focal plane detector is about 4:3, what is the approximate size of this optimal detector?

A 4:3 aspect ratio for 8×10^6 square pixels implies pixel numbers of 3266 by 2449. Assuming a square array with 1.47 μm spacing between pixels, this implies a sensor size of 4.8 mm x 3.6 mm.