

Name: _____

Homework 9 – Ast 281 – Spring 2009
Due Tuesday 4/14/09 – 12:00pm Wat 420 – 130 pts

1. What is the Drake Equation used for, and how accurate is it? [5]

2. In the early 1960s SETI pioneer Frank Drake began seriously thinking about how we might communicate with extra-terrestrial civilizations if they existed. Remember, unlike different cultures on Earth, which at least share the same environment, and some of the same experiences, there would probably be no commonality at all between alien cultures. So how do we communicate? Drake, and others reasoned that the easiest form of communication would be with pictures, and as we shall see that the best way to send the picture would be as a radio signal in the 1-10 GHz frequency range. A picture could be encoded as a series of 0's and 1's in a data stream, 0 representing white in the picture and 1 representing black. Also, consider that any civilization would send the data in a manner which would be the easiest possible means of decoding.
 - To encode a picture – imagine that it is drawn on a sheet of graph paper, and for each square with black in it, assign it the number 1 and each white square becomes 0. Assign numbers as if you were reading a text: *i.e. from upper left to lower right*, and this becomes the data stream for the image.
 - The picture would have unequal dimensions, each being a prime number. [Reminder – prime numbers cannot be divided by any other number, *e.g.* 1, 2, 3, 5, 7, 11, 13 etc.]. Thus, if the dimensions are prime numbers then the total data bits in the picture can be arranged only as a picture of $n \times m$ or $m \times n$ in size. The use of prime numbers means there are only 2 possible combinations of dimensions.
 - For example, if a message stream had 143 numbers in it. $143 = 11 \times 13$ or 13×11 and these are the only 2 divisors that can go into 143, so the picture can have only 2 possible orientations. To figure out the dimensions, assume that the picture will be almost square, and pick prime numbers close to the square root of the total. $12^2 = 144$, but 12 is not a prime number, so pick the nearest prime numbers to try: 11 or 13.

After the first US SETI meeting held in November 1961, Frank Drake came up with what he thought was a good message and sent it to participants of the meeting to see if they could decode it. He didn't give them any hints at all (*i.e.* like the ones I have given you above). Only a few of the scientists got anywhere with the message – and they were from the same culture and had just attended the same meeting on this new field of SETI.

- (a) Suppose you are conducting a SETI program and you detect an unusual radio signal from space near the 1420 MHz frequency. Why would your search be near 1420 MHz? [5]

- (b) This unusual signal is narrow band in frequency and continuously repeating. On the attached page is a binary representation of the signal received. Use a technique similar to that which would be used to decode Frank Drake's puzzle and the first signal sent into space from Arecibo (1974). The number of zeros and ones in this message is 2257. Record your answer on the graph paper attached [30]
- (c) How would you interpret this message? [10]

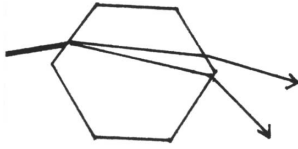
- (d) What do you think will be the effects on society after a first radio contact with an extra-terrestrial civilization? [Note: there is no single correct answer for this – if your answer is well thought out and justified you will get credit] [10].

3. This question deals with several of the properties of light and its interaction with matter. The following table gives you some useful indices of refraction for several substances.

Substance	n	Substance	n
Air	1.0003	Glass	1.4–1.9
Water	1.33	X	2.5
Water-ice	1.09	Y	3.2

- (a) What is the index of refraction? [5]
- (b) Is the velocity of light faster or slower in water compared to glass? [1] _____
- (c) Why does light slow down when it enters a medium? [5]

(d)

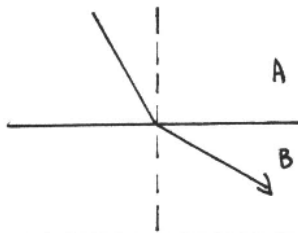


In the figure at the left, indicate which might be the light ray at 4000\AA and which might be at 6500\AA ? [2]

(e) What is refraction? [5]

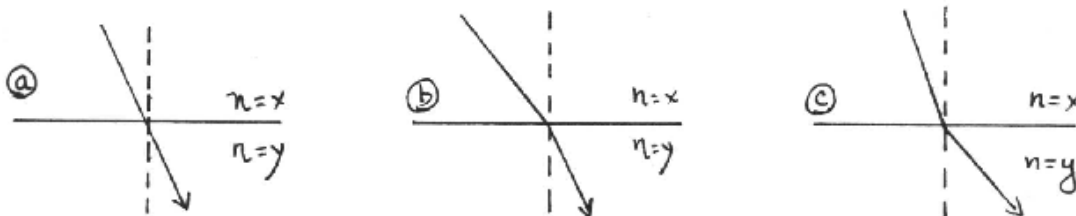
(f) What is diffraction? [5]

(g)

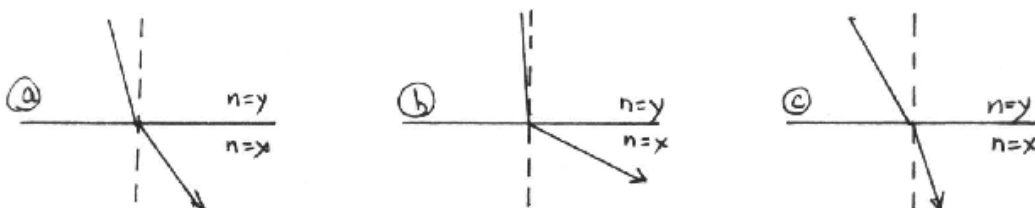


In the figure at the left, which substance has a higher index of refraction? [5] _____

(h) If light enters a medium of index of refraction of substance Y, from a medium of index of refraction of substance X, which of the figures below most accurately depicts how the light will behave? [5]



(i) Which of the figures below will be the opposite of the situation posed in part (h), *i.e.* light moving from a medium of index of refraction Y to that with index of refraction X? [5] _____



- (j) Will light be refracted at the frequency at which the energy in the atom or molecule is exactly equal to the spacing between energy levels in the atom? Why or why not? [5]

4. The next question deals with rainbow and atmospheric optics phenomena.

- (a) Why is the secondary rainbow (at 51°) fainter than the primary rainbow? [5]

- (b) Can you get rainbows in the winter in a climate where the temperature does not go above freezing? Why or why not? [5]

- (c) Suppose we visit some alien planet which has an atmosphere drastically different from ours in composition of the gases. In fact most of the clouds are composed of substance Y (see Question 3). Will “rainbows” on this planet be seen at angles of 42° from the anti-solar point? If not, will the angle be smaller or larger and why? [5]

- (d) Briefly discuss why rainbows are red on the outside, sundogs are red closer to the sun and corona or glory is red farthest from the sun (on the outside of the ring) [12].