Name:

Physics 122 – Spring 2013 – Test 1

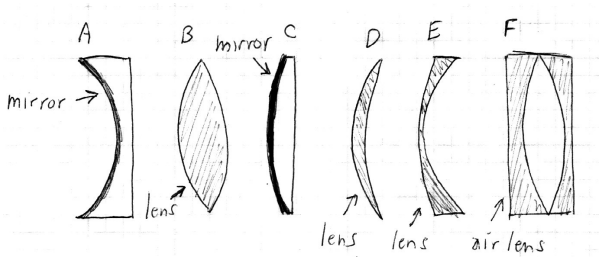
Instructions:

All answers should be decimal numbers (not functions or fractions) using scientific notation to three significant figures. SI units must be included on all answers. Angles may be given to the nearest degree. Note that a full trig table is provided at the end of this exam. If you use only your four-function calculator, you get a four point bonus. (Eight points for slide rule) You may use your 3x5 index card. No cel phones or other electronica are permitted. Show short answers on paper or in margins, but substantial work should be done on separate pages. Problems 1-5 require *only* an answer. You *may* provide an explanation for 1-5 if you want an opportunity for partial credit. Problems 6-12 require work to be shown in an orderly fashion. *IDEA* method is recommended but not required. Reasons are required for conclusions that do not follow directly from an equation, or when you are asked to explain.

1. *(5 pts.)* Mark each of the following statements about refraction true or false.

(a) Light rays refract when they cross an interface between materials with different refractive indices.
(b) Sound waves and Earthquake waves do not refract. Refraction is restricted to light waves.
(c) Radio waves do not refract. Refraction is restricted to light.
(d) Light rays refract when they slow down or when they speed up as they cross from one material to another.
(e) Total internal reflection can occur when light goes from a medium with smaller refractive index to one with larger refractive index.

2. *(5 pts.)* Circle all of the six lenses and mirrors would that would be said to have a negative focal length. Lens F, the air lens, is the same shape at lens B, but the shape is filled with air and embedded in glass, whereas lens B (and all the others) are glass, in air.



Problem 2: Circle all that have a negative focal length.

3. *(5 pts.)* Most American cel phones operate at 1900 MHz. What is the wavelength of these radio waves in air?

4. *(5 pts.)* The units for index of refraction are:

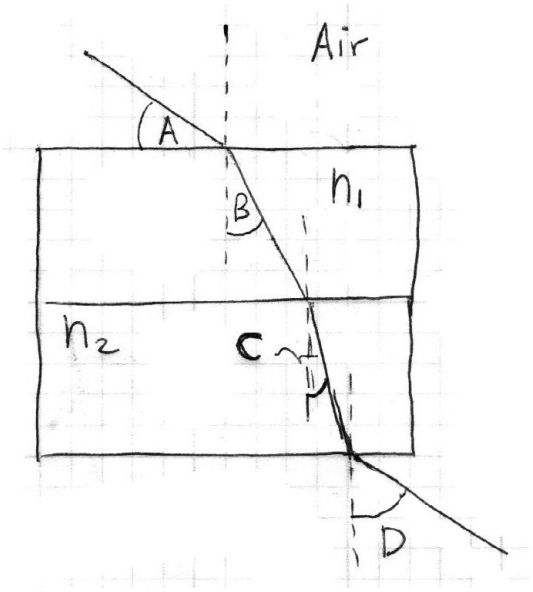
(a) meters per second
(b) meters per (second)^2
(c) Newton-seconds
(d) No units, dimensionless
(e) horsepower

5. *(5 pts.)* Two sources S_1 and S_2 oscillating in phase emit sinusoidal waves of wavelength 4.0 cm and equal amplitude. Point P is 8.00 cm from Source S_1 and 14.00 cm from Source S_2. At point P, there is

(a) Constructive interference
(b) Destructive interference
(c) Neither constructive nor destructive interference
(d) Not enough information given to decide

6. *(10 pts.)* The figure shows a red laser beam impinging on a slab of glass. The beam then passes into another solid material and then back to air. The angle $A = 40^o$.

(a) What is the value of angle B?
(b) You are told that the solid material (that is not glass) is something in the table of materials given below. What are the possible materials that the mystery material could be?
(c) What is the speed of light in the glass?
(d) What is the angle D? (and yes, you have enough information to answer this with a number in degrees)

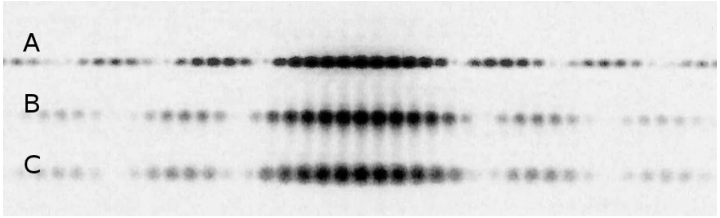


Problem 6: Light going through crown-glass and a mystery material. The dotted lines indicate normal lines to the slabs.

7. *(10 pts.)* Someone who claims to know the performance of spy satellites says that they can read the license numbers on construction trucks used to construct missile bases. What does physics tell you? Assume such a satellite is using a 3.0 m focusing mirror in a low earth orbit (150 km) and is pointing it straight down at Earth. Assume further that atmospheric turbulence can be ignored so that diffraction is the only limit. Assume still further that the truck you want to spy on is going steeply down hill so that its license plate is pointing upward toward the sky. Can the intelligence agent read the license plate? Ultimately you get a yes or no answer, but you must show the calculations and assumptions that lead to your answer. I will not be picky about factors of two. Just show your approach. (Hint: There are a couple of numbers that you need for your calculation that I did not tell you in the problem statement. Feel free to estimate these. They are part of your assumptions.)

8. *(5 pts.)* Below is a picture of three lasers passing through the same two narrow slits. The color has been lost in the picture, but you can figure it out.

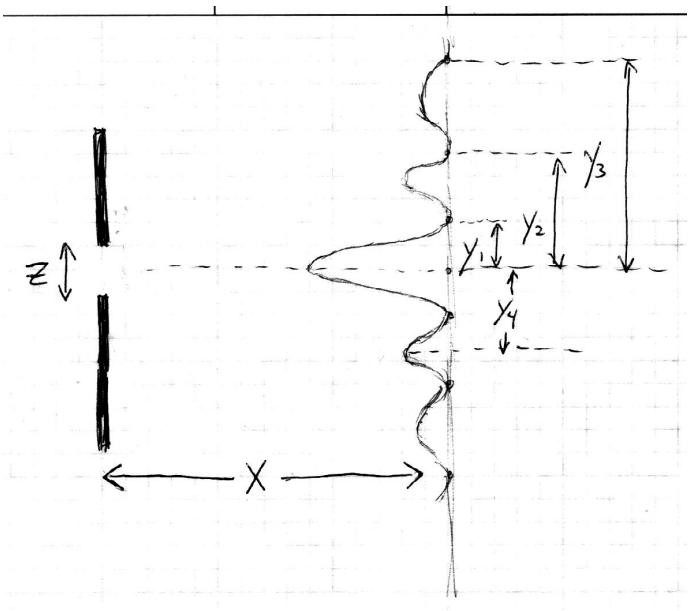
(a) If you know that one laser is red, one is yellow, and one is blue, indicate which is which.



Problem 8: Diffraction patterns from a red, blue, and yellow laser ... but which is which?

(b) If the small dots for red laser are one millimeter apart, how far apart are the dots for the blue laser?

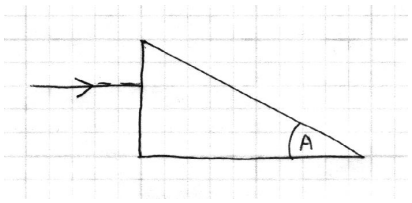
9. *(10 pts.)* Below is a single-slit diffraction pattern for a green laser. Calculate y_1 and y_4 given that $z = 2$ micrometer and X=33 cm (To save time, do not calculate y_2 or y_3.).



Problem 9: Single-slit diffraction pattern.

10. *(10 pts.)* A ray of light traveling in air enters a triangular piece of crown glass as shown. The figure below indicates the angle A.

Does the light ray emerge from the other side of the prism? If so, calculate the angle at which it emerges. If not, show (numerically) why not.



Problem 10: Angle $A = 30^o$.

11. *(10 pts.)* A mineral-oil film floats on water. The film thickness varies from 0.8 μm to 1.7 μm.

(a) If 650-nm light is incident normally on the film, where on the film (at what thicknesses) will there be enhanced reflection of the light? (Note: You should get multiple answers for this problem.)
(b) Explain (with a sketch and a sentence or two) how you figured out the answer to part "a". In other words, if you plugged into a formula to answer part a, explain why that formula is correct.

12. *(20 pts.)* A 7-mm high object is placed 20-cm from a concave mirror with focal length 15-cm.

(a) A 7-mm high object is placed 20-cm from a concave mirror with focal length 15-cm. Sketch a diagram of the situation which includes principal rays, object, image and focal point at approximately correct distances and sizes.
(b) Using an appropriate formula, calculate more precisely the image distance and the size of the image.
(c) State whether the image is real or virtual, and explain how you decided.
(d) Repeat parts a, b, c if the concave mirror is replaced by a concave lens whose focal length has the same magnitude as that of the concave mirror.

Visible Color	Wavelength (nm)
Violet	400
Blue	450
Green	530
Yellow	580
Orange	600
Red	640

Substance (phase)	Refractive index
Air (g)	1.0003
Ice (s)	1.31
Mineral Oil (l)	1.25
Water (l)	1.33
Ethanol (l)	1.361
Crown Glass (s)	1.50
Polycarbonate [Lexan] (s)	1.58
Garnet (s)	1.9
Diamond (s)	2.4

Trigonometry Table

Radian	Degree	Sine	Cosine	Tangent	Radian	Degree	Sine	Cosine	Tangent
0.000	0	0.000	1.000	0.000	0.803	46	0.719	0.695	1.036
0.017	1	0.017	1.000	0.017	0.820	47	0.731	0.682	1.072
0.035	2	0.035	0.999	0.035	0.838	48	0.743	0.669	1.111
0.052	3	0.052	0.999	0.052	0.855	49	0.755	0.656	1.150
0.070	4	0.070	0.998	0.070	0.873	50	0.766	0.643	1.192
0.087	5	0.087	0.996	0.087	0.890	51	0.777	0.629	1.235
0.105	6	0.105	0.995	0.105	0.908	52	0.788	0.616	1.280
0.122	7	0.122	0.993	0.123	0.925	53	0.799	0.602	1.327
0.140	8	0.139	0.990	0.141	0.942	54	0.809	0.588	1.376
0.157	9	0.156	0.988	0.158	0.960	55	0.819	0.574	1.428
0.175	10	0.174	0.985	0.176	0.977	56	0.829	0.559	1.483
0.192	11	0.191	0.982	0.194	0.995	57	0.839	0.545	1.540
0.209	12	0.208	0.978	0.213	1.012	58	0.848	0.530	1.600
0.227	13	0.225	0.974	0.231	1.030	59	0.857	0.515	1.664
0.244	14	0.242	0.970	0.249	1.047	60	0.866	0.500	1.732
0.262	15	0.259	0.966	0.268	1.065	61	0.875	0.485	1.804
0.279	16	0.276	0.961	0.287	1.082	62	0.883	0.469	1.881
0.297	17	0.292	0.956	0.306	1.100	63	0.891	0.454	1.963
0.314	18	0.309	0.951	0.325	1.117	64	0.899	0.438	2.050
0.332	19	0.326	0.946	0.344	1.134	65	0.906	0.423	2.145
0.349	20	0.342	0.940	0.364	1.152	66	0.914	0.407	2.246
0.367	21	0.358	0.934	0.384	1.169	67	0.921	0.391	2.356
0.384	22	0.375	0.927	0.404	1.187	68	0.927	0.375	2.475
0.401	23	0.391	0.921	0.424	1.204	69	0.934	0.358	2.605
0.419	24	0.407	0.914	0.445	1.222	70	0.940	0.342	2.747
0.436	25	0.423	0.906	0.466	1.239	71	0.946	0.326	2.904
0.454	26	0.438	0.899	0.488	1.257	72	0.951	0.309	3.078
0.471	27	0.454	0.891	0.510	1.274	73	0.956	0.292	3.271
0.489	28	0.469	0.883	0.532	1.292	74	0.961	0.276	3.487
0.506	29	0.485	0.875	0.554	1.309	75	0.966	0.259	3.732
0.524	30	0.500	0.866	0.577	1.326	76	0.970	0.242	4.011
0.541	31	0.515	0.857	0.601	1.344	77	0.974	0.225	4.331
0.559	32	0.530	0.848	0.625	1.361	78	0.978	0.208	4.705
0.576	33	0.545	0.839	0.649	1.379	79	0.982	0.191	5.145
0.593	34	0.559	0.829	0.675	1.396	80	0.985	0.174	5.671
0.611	35	0.574	0.819	0.700	1.414	81	0.988	0.156	6.314
0.628	36	0.588	0.809	0.727	1.431	82	0.990	0.139	7.115
0.646	37	0.602	0.799	0.754	1.449	83	0.993	0.122	8.144
0.663	38	0.616	0.788	0.781	1.466	84	0.995	0.105	9.514
0.681	39	0.629	0.777	0.810	1.484	85	0.996	0.087	11.430
0.698	40	0.643	0.766	0.839	1.501	86	0.998	0.070	14.301
0.716	41	0.656	0.755	0.869	1.518	87	0.999	0.052	19.081
0.733	42	0.669	0.743	0.900	1.536	88	0.999	0.035	28.636
0.750	43	0.682	0.731	0.933	1.553	89	1.000	0.017	57.290
0.768	44	0.695	0.719	0.966	1.571	90	1.000	0.000	∞
0.785	45	0.707	0.707	1.000					