Name:

Physics 122-02 Test 1B

Instructions:

No paper on desk. You may show short answers on paper or in margins, but substantial work should be done on back of exam pages. Problems 1-6 require *only* an answer. You *may* provide an explanation for 1-6 if you want an opportunity for partial credit. Problems 7-14 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. (For example you might need to state a theorem from geometry or trig.) If I cannot easily follow your reasoning, you will receive reduced or no credit.

Formulae are on page 4.

1. *(5 pts.)* Two sources S_1 and S_2 oscillating in phase emit sinusoidal radio waves of wavelength 1 mm and equal amplitude. Point P is 7.3 mm from Source S_1 and 4.8 mm 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

2. *(5 pts.)* Repeat previous question if P is 7.3 mm from Source S_1 and 5.0 mm from S_2.

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

3. *(5 pts.)* When we do ray tracing, we only trace two rays from the tip of the arrow. We don't trace rays from any other part of the object because:

(a) The sharp tip of the arrow scatters most of the light from the object.
(b) The shaft of the arrow is mostly specular reflection, so we don't get multiple rays with which to form an image.
(c) Any part of the arrow will work as long as it's not on the optical axis.
(d) All of the above.
(e) None of the above.

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

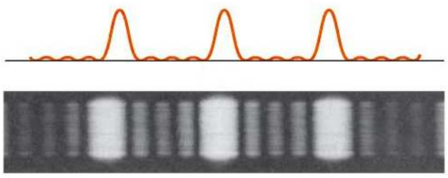
(a) meters per second

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

5. *(5 pts.)* Which of the following *two* statements are *not* required to be true for light to be coherent:

(a) It is all the same wavelength.
(b) It is totally internally reflected in glass.
(c) All the waves are the same phase.
(d) All the rays are pointed in the same direction.
(e) It is brighter than incoherent light.

6. *(5 pts.)* A beam of coherent light is directed at a slit apparatus. The resulting pattern is below. How many slits made the interference pattern below?



7. *(5 pts.)* You know how to do lens calculations. There were several physical assumptions that went into making sure that the lens equations and ray diagrams were valid. State the two most important of these assumptions. If you aren't sure which are the most important, you can state more than two, but star the two you think are probably the most important.

8. *(10 pts.)* Figure 1 shows a beam of light striking the top mirror, then the lower mirror, then being reflected away.

Given the angle $\theta_1 = 28°$ and $\alpha = 100^o$, calculate $\theta_2, \theta_3, \theta_4$, and δ as indicated in the figure. (δ is the angle the reflected ray makes with the incident ray.)

9. *(10 pts.)* Radio waves are a form of electromagnetic radiation similar to visible light in every way other than their lower frequency. When radio waves travel through ice, you can consider to be the same as light traveling through ice. Even the index of refraction may be assumed the same. Imagine a beam of radio waves from Albuquerque's 104.1 (the Edge) impinging on a flat slab of ice 10 m thick at an angle 50^o from the normal.

(a) Sketch the beam. Show its path entering, traveling inside, and leaving the ice again.

(b) What angle does the ray (or beam) make with the normal inside the ice?

(c) What is the wavelength of the radio waves inside the ice? (In case you did not know "104.1" means 104.1 MegaHertz).

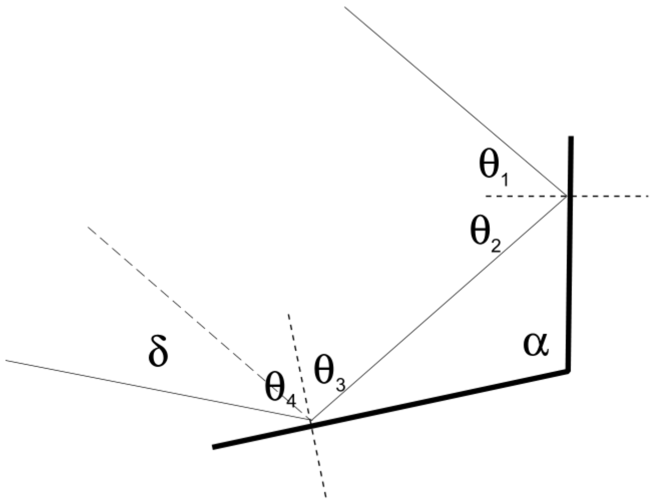


Figure 1: The light solid lines show the path of the light ray. The heavy solid lines are two mirrors with angle α between them. The short dashed lines are the normals to the mirrors. The long dashed line is parallel to the incoming light ray. It is provided to clarify the reference line for the deflection angle δ, which you are to find.

10. *(10 pts.)* A 14-mm high object is 20-cm from a convex lens with focal length 15-cm. Sketch a diagram of the situation which includes principal rays, object, image and focal point in approximately correct positions. Then calculate more precisely where, how large, and what type is the image.

11. *(5 pts.)* Repeat the previous problem, but replace the convex lens with a convex mirror.

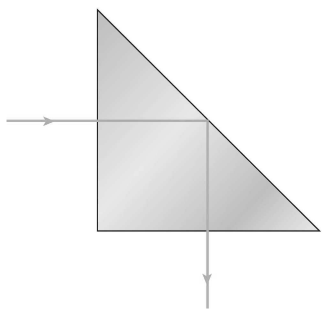


Figure 2: This prism is made from the semiprecious stone garnet. You may assume the light ray hits the angled surface at 45^o.

12. *(10 pts.)* Figure 2 shows a sketch of a light ray entering a right-angled prism made of the semi-precious stone "garnet". If the garnet is in air, all the light is internally reflected (as shown in the sketch). However, when the garnet is placed in certain fluids, some of the light emerges out of the angled facet.

(a) Which of the fluids listed in the table allow the light to emerge?

(b) For the fluid with the smallest index that allows the ray to escapes, calculate the angle at which the ray emerges and sketch the path of the emerging ray.

Substance (phase)	Refractive index
Air (g)	1.0003
Ice (s)	1.3
Water (l)	1.333
Glycerine (l)	1.473
Benzene (l)	1.501
Diiodomethane (l)	1.738
Garnet (s)	1.9
Diamond (s)	2.4

13. *(10 pts.)* Green laser light at 400 nm falls on a double-slit apparatus with slit separation 0.005 mm. Find the separation between the second and third bright fringes, as seen on a screen 2.0 m from the slits.

14. *(10 pts.)* Light impinges (from air) at normal incidence on part of a soap-bubble that is only 900 nm thick. Assume a soap-bubble has the same optical properties as water.

(a) Calculate the (longest) wavelength of light that will constructively interfere with itself in passing through the soap bubble. If you know the formula for this problem, you may use it.

(b) Regardless of whether you used a memorized formula in part (a), show Derive from first principles the formula which you needed to answer part (a). Your derivation should be supported by a sketch and one or two sentences regarding what happens when the light rays reflect off the various surfaces involved.

Useful Formulae

All are correct.	Some are relevant.	
$c = 3.00 \times 10^8\ m/s$	pv = nRT	$v = f\lambda$
$q = 1.6 \times 10^{-19}\ C$	v = c / n	$n_1\, sin(\theta_1) = n_2\, sin(\theta_2)$
$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$	$d\, sin(\theta) = m\lambda$	M $= -\frac{s'}{s}$
E = h f	p $= \frac{h}{\lambda}$	$a\, sin(\theta) = m\lambda$