Your name: _____

Total 15 problems, 7 pages. No separate solution sheets are necessary.

Read questions with care, and good luck with come to you!

For the following twelve multiple-choice problems, you can indicate your answer by drawing a circle around one of the choices. The best choice is unique for each problem. No explanation is necessary.

Each multiple-choice problem is worth 1 point.

Problem 1 A loudspeaker is blasting sound at 80 dB. You add three more loudspeakers, and so now there are four loudspeakers in total, each blasting sound at 80 dB. What is the total sound intensity level?

(a) 81 dB (b) 83 dB (c) 86 dB (d) 89 dB (e) 320 dB

Problem 2 Two sound waves with similar frequencies are superposed. The resultant total sound wave can be represented by $D(x,t) = f_f(x,t)f_s(x,t)$, where f_f is a function governed by a fast frequency and f_s is a function governed by a slow frequency, and D is the total local displacement. The beat frequency represents the frequency of _____.

(a) f_f (b) f_s (c) f_f^2 (d) f_s^2

Problem 3 In an open tube, a standing sound wave is formed. Let $D(x,t)$ be the displacement field, and $\Delta P(x,t)$ be the pressure field, for the sound wave. ΔP represents the deviation from the equilibrium pressure. The open ends of the tube are

(a) nodes for $D(x,t)$, and nodes $\Delta P(x,t)$.

(b) anti-nodes for $D(x,t)$, and anti-nodes for $\Delta P(x,t)$.

(c) nodes for $D(x,t)$, and anti-nodes for $\Delta P(x,t)$.

(d) anti-nodes for $D(x,t)$, and nodes for $\Delta P(x,t)$.

Problem 4 You are driving at 50 m/s on a straight segment of a highway. A police car is behind you, following you at the same speed. The police car has turned on a siren. The siren produces sound at a frequency of 1.0 kHz. What frequency does the siren sound to you? Assume that the speed of sound is 340 m/s.

(a) 1.3 kHz (b) 0.7 kHz (c) 1.0 kHz (d) 1.5 kHz

Problem 5 In Monet's "Impression, Sunrise," the image of the Sun reflected off the water is not a circle, but a long streak consisting of multiple patches, because

(a) the water surface is rough at any given moment and thus the law of reflection is valid only for each small portion of the water surface.

(b) the water surface is rough at any given moment and the law of reflection is invalid on all length scales.

(c) the water surface was smooth and Monet was including multiple perspectives in one painting.

(d) Monet was ignoring the reality completely.

Problem 6 Are there known materials with index of refraction $n < 1$ (limit to the usual materials with $n > 0$)?

(a) Yes, sure, e.g. n can be, like, 0.9. (b) No, not in the current science.

Problem 7 In an amusement park, you notice a strange mirror. As you walk directly towards the mirror, you notice that your reflected image flips as you walk past the point of distance 1 m from the mirror. Assuming that the mirror is a spherical mirror, which of the following statements is true? (radius $\equiv |r|$)

(a) The mirror is a convex mirror, and its radius of curvature is 1 m.

(b) The mirror is a convex mirror, and its radius of curvature is 2 m.

(c) The mirror is a concave mirror, and its radius of curvature is 1 m.

(d) The mirror is a concave mirror, and its radius of curvature is 2 m.

Problem 8 You are looking at yourself in a shiny 9.4 cm diameter Christmas tree ball. Your face is 21.5 cm away from the ball's front surface. Your image is

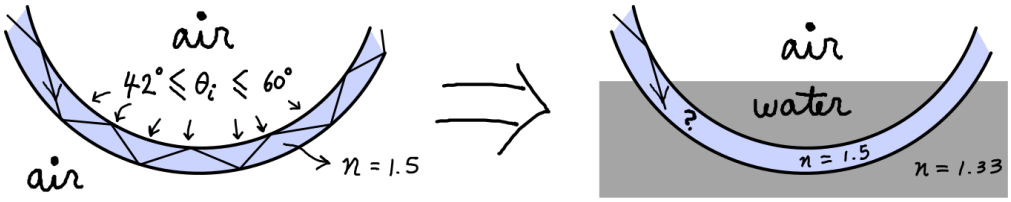
(a) real and upright.

(b) virtual and upright.

(c) real and inverted.

(d) virtual and inverted.

Problem 9 An optical fiber cable is used to transmit light. The index of refraction for for the optical fiber cable is 1.5. The cable is bent as shown, but light is transmitted perfectly through the cable, since the angle of incidence θ_i inside the cable satisfies $42° \le \theta_i \le 60°$ throughout the bent section. What happens if water surrounds part of the cable, as shown?



(a) No change. Still perfect transmission of light.

(b) Transmission is reduced, but some light is transmitted.

(c) No transmission of light anymore.

Problem 10 Which of the following statements is false? part (b), o K.

(a) A virtual object is always imaged to a real image by a converging lens.

(b) A real object (at a non-zero distance from mirror) is always de-magnified by a convex mirror, i.e., $|m| < 1$.

(c) It is always possible to see, with eye, a real image formed by a mirror or a glass lens.

(d) Angular magnification of a converging lens is a more appropriate measure of the resolving power of the lens than lateral magnification.

Problem 11 In Young's double slit experiment, a slab of glass of a certain small thickness is placed behind one of the two slits so that the light coming out that slit has a fixed relative phase shift by $\pi/2$, compared to the light coming out of the other slit. What happens to the interference pattern?

(a) No change.

(b) The positions of maxima and minima are exchanged.

(c) Pattern shifts by approximately half the distance between neighboring maximum and minimum.

(d) Pattern disappears since now the light is incoherent.

Problem 12 A soap bubble is made of a thin layer of soapy water of thickness 1000 nm. The index of refraction of the soapy water is 1.4. You are looking directly at a bubble, and the front part of the bubble looks _____.

(a) yellow (570 nm) (b) green (510 nm) (c) blue (475 nm) (d) violet (400 nm)

For the following three problems, you must provide short but sufficient derivations. Answer alone will not get you much credit, even if it is correct.

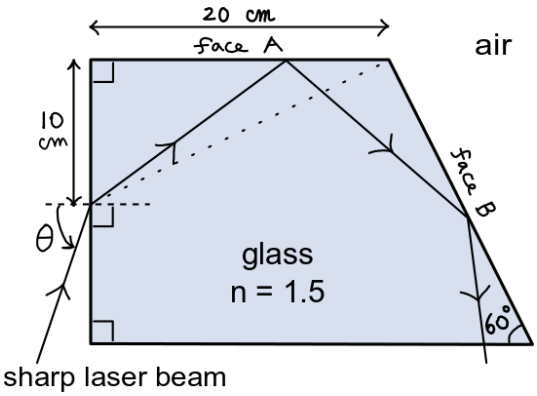
Proceed to the next page to start short writing problems.
If your solution overflows one page, then continue to the last blank page or this blank page.

Problem 13 (3 points) In a playground, there are many children running about. At any given random time, each child is making a sound of 1.0 kHz, is running at speed 1.0×10^1 m/s in a completely random direction. You are a stationary observer of sound. Find the "Dopper broadening" ratio $\Delta f/f$, where f is the mean frequency (1.0 kHz), and Δf is the width of the distribution of frequencies that you hear. Here, we shall simply take Δf as the difference between the maximum possible frequency that you can hear and the minimum possible frequency that you can hear. Take the speed of sound to be 340 m/s.

Your solution:

Problem 14 (4 points) Consider a prism, whose cross section is shown in the diagram below. All four faces (which include the marked faces A and B) surrounding this cross sectional area are perpendicular to the plane of this paper. A sharp laser beam is aimed upward as shown in the diagram, hits the left surface exactly at 10 cm from the top and at a variable angle θ, and enters the prism. The laser beam is contained completely in the plane of this paper. Find the condition for θ values under which the laser beam will go through total internal reflections on the top face (face A) and on the right face (face B).

Your solution:



Problem 15 (5 points) One morning, Ray realizes that the far points of both his eyes have decreased to 50 cm and the near points have decreased to 18 cm. He goes to an optometrist, who confirms this finding and gets a pair of glasses made for Ray. When Ray wears his new glasses, his glasses sit 2.0 cm in front of his eyes.

(a) What should be the prescription (in D, diopters) for the glass lens (for either eye), assuming it has restored the normal far point for Ray?

(b) What is Ray's new effective near point with this corrective lens?

(c) One lens surface of the corrective lens is convex with the radius of curvature 10 m. Determine whether the other lens surface of the corrective lens is convex or concave and what its radius of curvature is. Assume that the index of refraction for the lens material is 1.5.

Your solution: