Phyx 135-3 (10 am) Midterm I **Name: ____________________________**

Winter 2017 **Discussion Section: _________________**

1) (10 points) Two loudspeakers (which may be considered as point sources) are producing incoherent rock music. The sound intensity from only the left-hand speaker, at one meter directly in front of the speaker, is 100 dB. The sound intensity from only the right-hand speaker, at one meter directly in front of the speaker, is 90 dB. If the two speakers are setting three meters apart, what is the total sound intensity (in dB) at a point four meters directly in front of the right speaker?

Solution

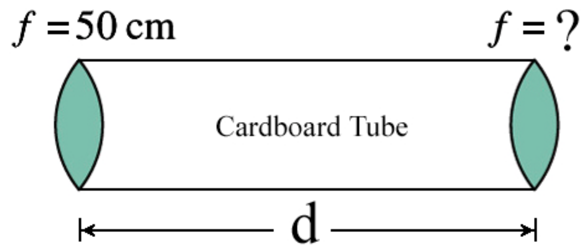
The sound intensity from the left speaker (at one meter) is given by: $100 = 10\log(I/I_o)$, which can be quickly inverted to give $I_L = 0.01$ W/m^2. Likewise, the sound intensity from the right speaker (at one meter) is quickly given by: $90 = 10\log(I/I_o)$, which yields $I_R = 0.001$ W/m^2.

Now, at a point four meters in front of the right speaker, the right-hand intensity will be $4^2 = 16$ times smaller than the intensity at one meter, or $0.001 / 16 = 6.25 \times 10^{-5}$ W/m^2.

Using the Pythagorean Theorem, we see that this same point is $(3^2 + 4^2)^{1/2} = 5$ meters from the left-hand speaker, so the left-hand intensity will be $0.01 / 25 = 4 \times 10^{-4}$ W/m^2.

The total sound intensity in dB is thus: $I = 10\log[(6.25 \times 10^{-5} + 4 \times 10^{-4}) / 10^{-12}] = 86.7$ dB

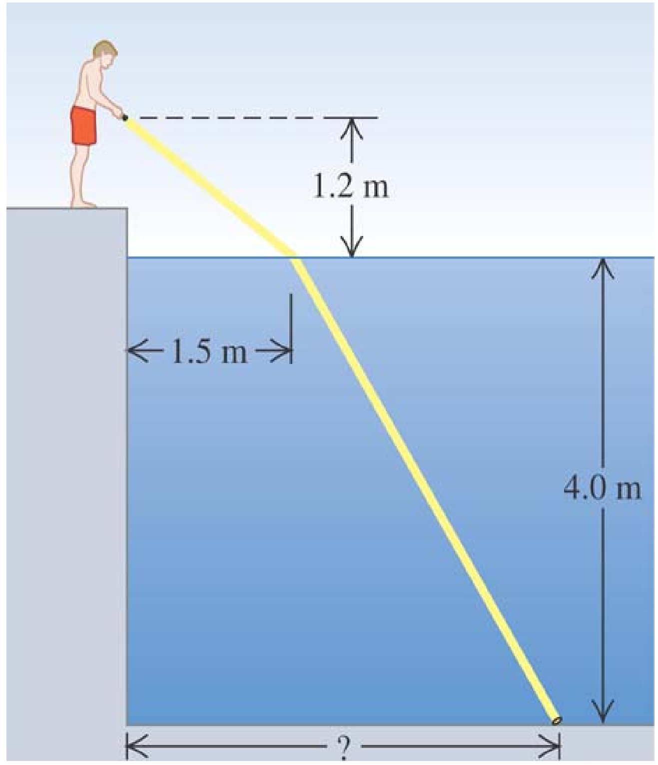
2) (8 points) I decide to make a telescope out of two convex lenses and a cardboard tube. The objective lens' focal length is 50 cm. I don't know the focal length of the eyepiece lens. I experiment with different distances between the lenses and find one that brings the Moon into perfect focus with a magnification of 10 times. (I can comfortably view the image with my eyes focused at infinity.) What is the separation d of the lenses?



Solution

The magnification of a telescope is $M = -f_O / f_E$, so the focal length of the eyepiece is:
$10 = 50\text{ cm} / f_E$, or $f_E = 5$ cm. The length of a refracting telescope is always $f_O + f_E$, so
$L = 50 + 5 =$ 55 cm.

3) (10 points) As shown at right, a boy is holding a flashlight 1.2 m above a pool of water. If the light ray strikes the pool 1.5 m from the boy, and the pool is 4.0 m deep, how far from the shore will the light ray strike the bottom of the pool? The index of refraction of water is $^4/_3$.



Solution

As measured from the normal, the angle of the light ray striking the water is given by $\tan\theta_1 = 1.5 / 1.2$, or $\theta_1 = 51.34°$

From Snell's Law, $(1.00)\sin(51.34°) = (1.333)\sin\theta_2$, or $\theta_2 = 35.86°$

From the figure, we see that the tan of θ_2 is given by the unknown distance "x" along the bottom of the pool (where x = "?" minus 1.5 m), divided by 4.0 m. So, $\tan(35.86°) = x/4$ means $x = 2.89$ m, and the total distance "?" from shore is 4.39 m.

4) (8 points) Two lasers, one with $\lambda = 470$ nm (blue) and one with $\lambda = 660$ nm (red) are shining through a diffraction grating where the slits are separated by 0.03 mm. There is a screen 5.0 meters in front of the grating. How far apart are the first-order lines of the lasers on the screen?

Solution

From $d \sin\theta = m\lambda$, with $m = 1$, we have $\theta = \sin^{-1}(470 \text{ nm}/0.03 \text{ mm}) = 0.898°$ for the blue laser, and $\theta = \sin^{-1}(660 \text{ nm}/0.03 \text{ mm}) = 1.261°$ for the red. This gives a separation of $1.261° - 0.898° = 0.363°$, or $(\pi/180)(0.363) = 0.00634$ rad. Using $\tan\theta \approx \theta = y/L$, we have $y = (5 \text{ m})(0.00634 \text{ rad}) = 3.17$ cm.

______ **5) (2 points)** A pipe that is open at both ends is resting on a rock in the methane atmosphere of Titan. The pipe is 41 cm long. The lowest tone that the pipe can produce as the wind blows past is 575 Hz. What is the speed of sound in Titan's atmosphere?

A) 940m/s	B) 470 m/s	C) 340 m/s
D) 235 m/s	E) 170 m/s	F) 85 m/s

Ans: B

For a pipe open at both ends, the longest possible resonant wavelength is $\lambda = 2L = 82$ cm. We have $f = 575$ Hz, so $v = f\lambda = (575)(0.82) = 471$ m/s.

______ **6) (2 points)** An electromagnetic wave is generated by:

A) only charges moving sinusoidially
B) a changing magnetic field
C) any moving charge
D) any accelerating charge
E) only a charge with a changing acceleration
F) only a charge moving in a circle

Ans: D

7) (10 points) A bat flying at 8 m/s to the east encounters an insect flying to the west. The bat emits an ultrasonic chirp at 125 kHz, and hears an echo of 132.5 kHz come back. (That is, the chirp has been reflected off the insect.) How fast is the insect flying? You may assume that the speed of sound in air is 343 m/s.

Solution

The sound emitted by the bat will be "heard" by the insect at a frequency f_L of:
$f_L = (125{,}000)(343 + v)/(343 - 8)$, where v is the speed of the insect, and where we have chosen the plus/minus signs based on the fact that the bat and the insect are approaching each other. This frequency (f_L) will be reflected from the insect and Doppler-shifted a second time as it heads back towards the bat. The bat hears 132,500 Hz, so we have: $132{,}500 = f_L(343 + 8)/(343 - v)$. Substituting for f_L and doing the algebra yields:

$132{,}500 = (125{,}000)(343 + v)(351) / (335)(343 - v)$, or $1.0117 = (343 + v)/(343 - v)$,
or $347 - 1.0117\,v = 343 + v$, or $v =$ 1.99 m/s.