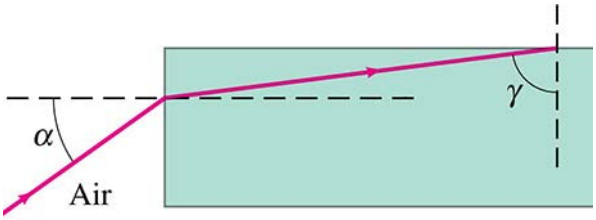
Physics 135-3, Quiz #2 Solutions

1) (10 points) You are driving down a highway at 27 m/s. Directly in front of you, an ambulance is approaching with a siren wailing. Since you have perfect pitch, you can hear that the siren is sounding at 1200 Hz. However, you happen to know that the siren actually sounds at 1000 Hz when the ambulance is standing still. How fast is the ambulance moving? You may assume that the speed of sound in air is 343 m/s.

Solution

We start with the Doppler equation, $f = f_o (c \pm v_L) / (c \pm v_S)$. In this problem you are moving towards the sound source, and it is moving towards you, so both motions are trying to raise the sound frequency. This means we need a plus sign on the top of the equation and a minus sign on the bottom to make the fraction as large as possible. Inserting numbers gives us:
$1200 = 1000(343 + 27)/(343 - v_S)$. A bit of algebra yields $v_S = 343 - 370 / 1.2 =$ 34.67 m/s.

2) (10 points) You are sending light down an optical fiber which has an index of refraction of 1.30, as shown at right. What is the maximum entry angle α for which light entering the fiber will actually propagate far down the fiber?



Solution

We must have total internal reflection for the light to propagate down the fiber, or in other words, the angle γ must be greater than θ_c. Since $\sin\theta_c = 1/n = 1 / 1.30$, we have $\theta_c = 50.28°$

This tells us that the refraction angle must be at least $90° - 50.28° = 39.72°$. Using Snell's Law, we have: $(1.00)\sin\alpha = (1.30)\sin(39.72°)$, or $\alpha =$ 56.18°