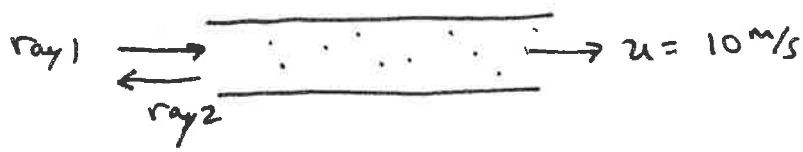
EX 31.3 (Speed of light in flowing water)



a) Since the index of refraction of water is $n = 1.33$,

$$v = \frac{c}{n} = \frac{3e8 \, m/s}{1.333} = 2.25 \times 10^8 \, m/s .$$ This is

the speed of light in stationary water.

If the water is flowing, we must add the speed of the water to that of the light according to

$$v_1' = \frac{v + u}{1 + \frac{v \cdot u}{c^2}} = \frac{\frac{c}{n} + 10}{1 + \frac{\frac{c}{n} \cdot 10}{c^2}} = 225{,}056{,}268.438$$

and

$$v_2' = \frac{v - u}{1 - \frac{v \cdot u}{c^2}} = 225{,}056{,}259.694$$

These are the speeds of the beams with respect to the pipe. Notice they are different.

b)

Ex 31.3 (Cont'd)

b) • The # of wavelength in a tube is the length of the tube divided by the wavelength of the light.

• The wavelength of the light is given by $v = \lambda f$

or $\lambda = \frac{v}{f}$

• The frequency of a He Ne laser is $f = 4.73755e14$ Hz

• The downstream wavelength is

$$\lambda_d = \frac{225{,}056{,}268 \text{ m/s}}{4.73755e14 \text{ Hz}} = ~~4.750{,}478\ e\text{-}7~~$$

$$= 4.750{,}477{,}96e\text{-}7 \text{ m}$$

• So $n_d = \frac{10 \text{ m}}{\lambda_d} = 21{,}050{,}513.42$

• The upstream wavelength is $\lambda_u = \frac{225{,}056{,}259}{4.73755e14} =$

$$= 4.750477{,}77\ e\text{-}7 \text{ m}$$

$$n_u = \frac{10 \text{ m}}{\lambda_u} = 21{,}050{,}514.24$$

• So about an extra 0.8 wavelengths fit in the upstream beam.

• This is possibly measurable using interferometry, as described by Einstein in Sec. XIII of Relativity.