Worksheet #12

PHYS 4C: Waves and Thermodynamics

Donald Aingworth IV

November 17, 2025

1 Problem 1

Without looking anything up, determine what a light year is in meters.

1.1 Solution

I assume we know the speed of light to be $c = 2.998 \times 10^8\,\text{m/s}$. We first find the conversion factor of seconds per year.

$$1\text{ s} \times \frac{1\text{ min}}{60\text{ s}} \times \frac{1\text{ hr}}{60\text{ min}} \times \frac{1\text{ day}}{24\text{ hr}} \times \frac{1\text{ yr}}{365.25\text{ day}} = \frac{1\text{ yr}}{31557600} \tag{1}$$

Multiply the speed of light by the reciprocal of the conversion factor to find the distance light travels in a year.

$$c = 2.998 \times 10^8\,\text{m/s} \times 31557600\text{ s/yr} = 9.46 \times 10^{15}\text{ m/yr} \tag{2}$$

Multiply this by 1 year to find that one lightyear is equal to $\boxed{9.46 \times 10^{15}\,\text{m}}$

2 Problem 2

Unpolarized light travelling in the z-direction is incident upon three polaroid filters with pass directions given by $+35°$, $-40°$, and $+25°$ counter-clockwise from $+x$. Determine the fraction of the original light which passes through the three filters.

2.1 Solution

Divide it into four parts with four intensities for the light: initially (I_0), then after passing through the first (I_1), second (I_2), and third (I_3) filters. First, the the first filter will filter out half the light's intensity.

$$I_1 = \frac{1}{2} I_0 \tag{3}$$

Next, the second filter is $35^\circ - (-40^\circ) = 75^\circ$ away from the first polarization direction. This can be used to find I_2.

$$I_2 = I_1 \cos^2(75^\circ) = \frac{1}{2} \cos^2(75^\circ) I_0 \tag{4}$$

Last, the third filter is $-40^\circ - 25^\circ = -65^\circ$ away from the first polarization direction. This can be used to find I_3.

$$I_3 = I_2 \cos^2(-65^\circ) = \frac{1}{2} \cos^2(-65^\circ) \cos^2(75^\circ) I_0 \tag{5}$$

$$= 0.00598 I_0 \tag{6}$$

This tells is that the amount that passes through is $\boxed{0.00598}$.