Physics Department

Physics 335	Spring 2022	First Hour Exam

1. Find the resultant wave resulted from adding the three waves given below.

$$\begin{aligned} y_1 &= 2\cos(kx - \omega t) \\ y_2 &= 3\cos(kx - \omega t + \frac{\pi}{6}) \\ y_3 &= 4\cos(kx - \omega t + \frac{\pi}{4}) \end{aligned}$$

2. A point source of light is 100 cm below the surface of a swimming pool. Find the radius of the largest circle at the surface of the pool through which light from the point source of light can emerge. The index of refraction of water is 1.33.

3. Red and violet light hit a prism with a 60^0 apex angle in the minimum deviation configuration. if the index of refraction of the prism for red and violet light are respectively 1.514 and 1.523, What is the angular separation between the two emerging colours.?

4. (a) Find the focal length of a thin plano-convex lens (curved surface to the left) made of glass of index of refraction 1.5. take the radius of curvature of the of the curved surface to be 2.5 cm.

   (b) A small object of length 1 cm is placed 20 cm to the left of the lens. Find the image location and length

5. A small candle is placed 6 cm in front of a concave mirror having a radius of curvature of 40 cm. Find the position of the candle's image and its magnification. Describe the image then draw ray diagram to show your results.

(Q1) $y_1 = 2\cos(kx - \omega t)$

$y_2 = 3\cos(kx - \omega t + \frac{\pi}{6})$

$y_3 = 4\cos(kx - \omega t + \frac{\pi}{4})$

$y_{tot} = y_1 + y_2 + y_3 = Re\left[e^{i(kx-\omega t)}\left(2 + 3e^{i\frac{\pi}{6}} + 4e^{i\frac{\pi}{4}}\right)\right]$

$= Re\, e^{i(kx-\omega t)}\left[\left(2 + 3\cos\frac{\pi}{6} + 4\cos\frac{\pi}{4}\right) + i\left(3\sin\frac{\pi}{6} + 4\sin\frac{\pi}{4}\right)\right]$

$= Re\, e^{i(kx-\omega t)}\left[\left(2 + 2\frac{\sqrt{3}}{2} + \frac{4}{\sqrt{2}}\right) + i\left(\frac{3}{2} + \frac{4}{\sqrt{2}}\right)\right]$

$= Re\, e^{i(kx-\omega t)}\left[7.43 + i(4.33)\right]$

$= \sqrt{(7.43)^2 + (4.33)^2}\cos(kx - \omega t + \phi)$

$= 8.6\cos(kx - \omega t + \phi)$

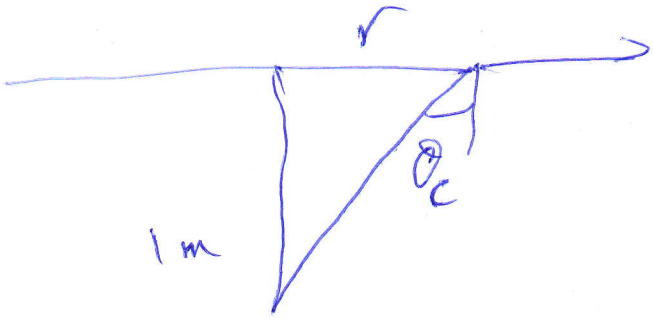
$\phi = \tan^{-1}\frac{4.33}{7.43} = 0.528$

$y_r = 8.6\cos(kx - \omega t + 0.528)$

Q2)

$$n_w \sin\theta_c = n_a \sin\frac{\pi}{2}$$

$$\sin\theta_c = \frac{n_a}{n_w} = \frac{1}{1.33}$$

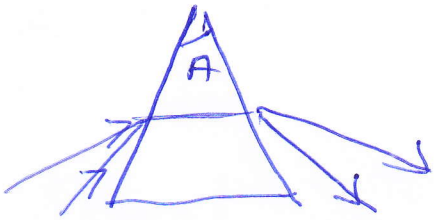


$$\theta_c = 0.85 \text{ rad}$$

$$\tan\theta_c = 1.14 = \frac{r}{100}$$

$$r = 114 \text{ cm}.$$

Q3) $$\frac{n_p}{n_m} = \frac{\sin\frac{1}{2}(A+D)}{\sin\frac{1}{2}A}$$



Red light $n_p = 1.514$

$$1.514 = \frac{\sin\frac{1}{2}(A+D)}{\sin\frac{1}{2}A}$$

$$\sin\tfrac{1}{2}(A+D) = 1.514 \times 0.5 = 0.757$$

$$D_r = 38.40^\circ$$

for violet light, $n_v = 1.523$

$$D_v = 39.19^\circ$$

$$\Delta D = 39.19^\circ - 38.4^\circ = 0.81^\circ$$

(Q4) a) $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$= (1.5-1)\left(\frac{1}{2.5} - \frac{1}{\infty}\right)$

$= 0.2\ cm^{-1}$

$f = 5\ cm.$

b) $\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f} \Rightarrow \frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o}$

$= 0.2 - \frac{1}{20} = \frac{3}{20}$

$s_i = \frac{20}{3} = 6.67\ cm$

$h_i = -\frac{s_i}{s_o} h_o = -\frac{6.67}{20} \times 1 = -0.34\ cm$

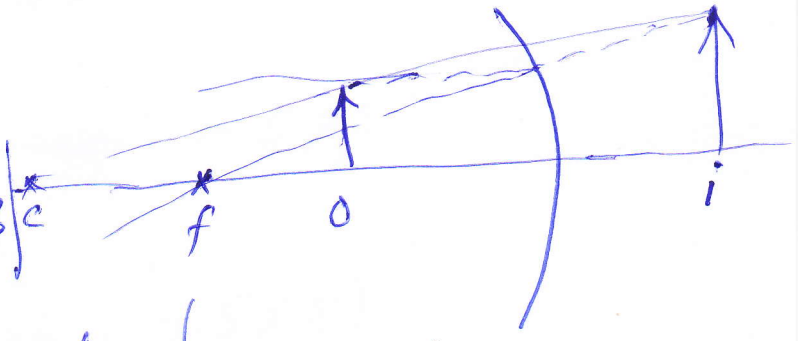
image is inverted, smaller and real.

(Q5) $\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{f} \Rightarrow \frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o} = \frac{1}{20} - \frac{1}{6} = -0.1167$

$s_i = -8.57\ cm$

~~The image is~~

$m = -\frac{s_i}{s_o} = \frac{8.57}{6} = 1.43$



The image is upright, enlarged, and virtual