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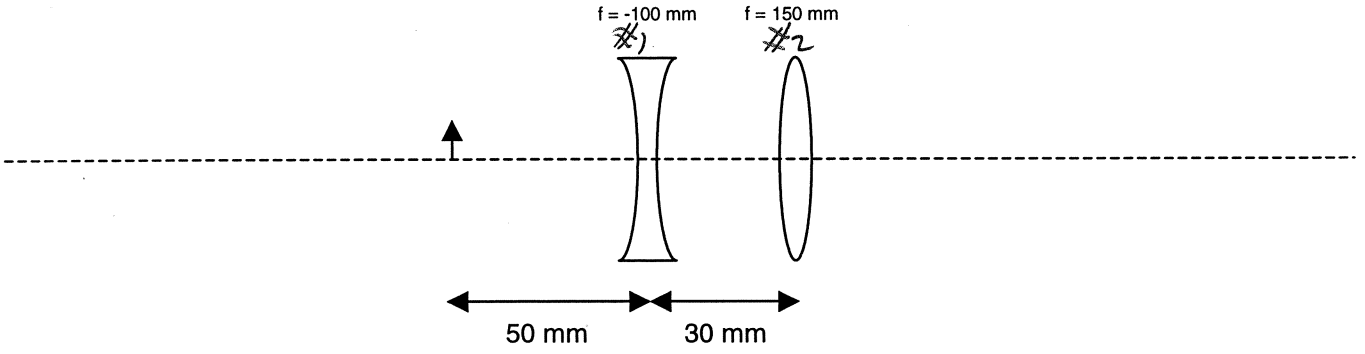
Recitation Instructor: Cardwell Griffith Nilsen Schoun Shiroyanagi Willis

Problem 1, 24 points. **(a)** Measured from the position of the second lens, where is the image formed by the lens system shown below? Be clear on whether it is to the left or right of the lens. **(b)** Is the image real or virtual? **(c)** What is the magnification of the image?



$p_1 = 50\ mm$, $f_1 = -100\ mm$ → $\frac{1}{f} = \frac{1}{p} + \frac{1}{i}$ → $i_1 = -33.3\ mm$ $\quad m_1 = -\frac{i_1}{p_1} = \frac{2}{3}$

$p_2 = |i_1| + 30mm = 63.3\ mm$ → $i_2 = -109.6mm$

$f_2 = 150mm$ $\quad m_2 = -\frac{i_2}{p_2} = 1.73$

image location: 110 mm to left of 2nd lens

image is virtual

$m = m_1 m_2 = +1.15$

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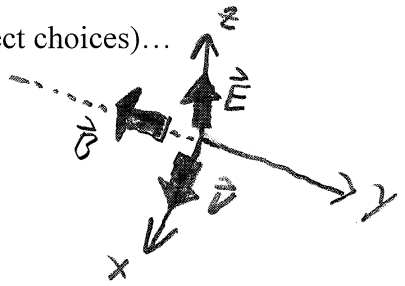
Problem 2, 24 points. A beam of light with a 488 nm wavelength is traveling in vacuum in the positive x direction. At t = 0 and x = 0, the electric field reaches its maximum magnitude of 300 V/m and is pointing in the positive z direction.

(a) At t = 0 and y = 0 the magnetic field is pointing in the (circle the correct choices)…

negative positive **x y z** direction.



(b) Let the light's magnetic field be described as: $B = B_m \sin(kx \pm \omega t + \phi)$.
Find B_m, k, ω, φ and indicate whether the "+" or "-" should be used. (There are multiple values that φ can have. Just supply one.)

$B_m = \frac{E_m}{c} = 1.00\ \mu T$

$k = \frac{2\pi}{\lambda} = 1.29 \cdot 10^7\ rad/m$

$\omega = ck = 3.86 \cdot 10^{15}\ rad/s$

$\phi = \frac{\pi}{2}$ because at $x=0, t=0$ $B = B_m$

so $B_m = B_m \sin\phi$.

(c) The light then enters a block of glass with an index of refraction of 1.75. Now what are k and ω?

$k = \frac{2\pi}{\lambda_{glass}} = \frac{2\pi}{\lambda/n} = n\left(\frac{2\pi}{\lambda}\right) = 2.25 \cdot 10^7\ rad/m$ ✓

$\omega = 3.86 \cdot 10^{15}\ rad/s$ ✓

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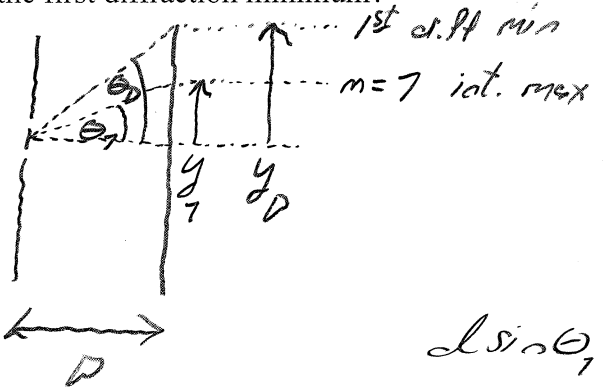
Problem 3, 18 points. 632 nm light illuminates a double slit with a slit width of 12.8 μm and a slit separation of 1.20 mm. The viewing screen is 1.55 m away. What is the distance between the m=7 interference maximum and the first diffraction minimum?

→ call this Δy



$y_7 = D\tan\theta_7 \approx D\theta_7$

$y_0 = D\tan\theta_0 \approx D\theta_0$

$\Delta y = |y_0 - y_7|$

$d\sin\theta_7 = 7\lambda \Rightarrow \theta_7 \approx \frac{7\lambda}{d}$

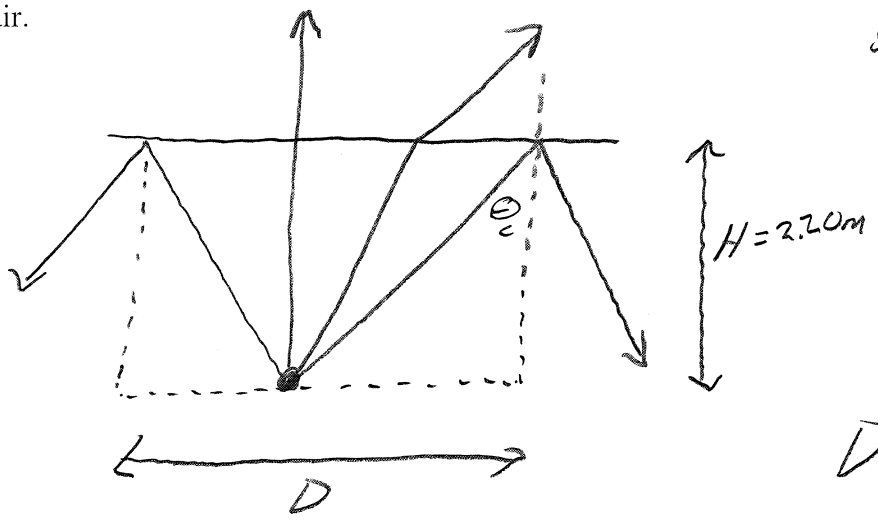
$a\sin\theta_0 = \lambda \Rightarrow \theta_0 \approx \frac{\lambda}{a}$

$\Delta y = \left|\frac{D\lambda}{a} - \frac{D7\lambda}{d}\right| = D\lambda\left|\frac{1}{a} - \frac{7}{d}\right|$

$D = 1.55\ m$
$d = 1.20\ mm$
$a = 12.8\ \mu m$

$= 7.08\ cm$ ✓

Problem 4, 10 points. A point source of light is 2.20 m below the surface of a pool containing a liquid with $n_{liquid} = 1.83$. Find the <u>diameter</u> of the circle at the surface through which the light emerges from the pool into air.



$\sin\theta_c = \frac{1}{1.83}$

$\theta_c = 33.1^\circ$

$\tan\theta_c = \frac{D/2}{H}$

$D = 2H\tan\theta_c$

$= 2.87\ m$ ✓

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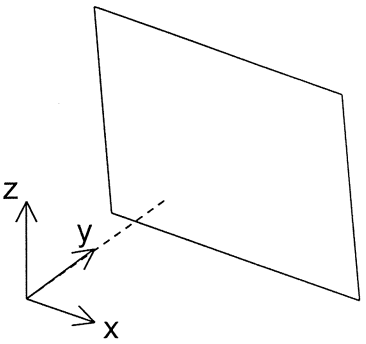
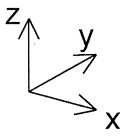
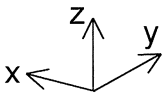
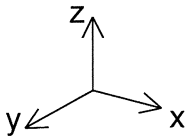
Problem 5, 24 points.

(A) An xyz coordinate system is placed in front of a mirror as shown to the right. The image of the coordinate system looks most like:



(a) 

(b) 

(c) 

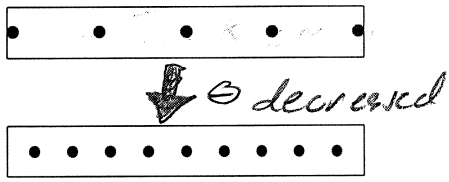
(B) Consider a two-slit interference apparatus illuminated by a laser. Which of the following will change the phase difference between waves arriving at the m = 2 bright fringe on a screen? ***Circle <u>every</u> correct choice. There may be more than one correct choice or none of the choices may be correct.***

(a) immersing the apparatus in water **(b)** increasing the spacing between slits

(c) moving the screen away from the slits **(d)** changing the frequency of the light

None of these choices are correct. $\Delta\phi = m2\pi = 4\pi$.
However, I decided I didn't like this question so no points will be deducted.

(C) A laser illuminates a double-slit and the result is displayed on a screen. The figure shows the screen before and after a change is made to the double slit apparatus. ***Circle <u>every</u> correct choice. There may be more than one correct choice or none of the choices may be correct.***



(a) increasing the wavelength **(b)** decreasing the wavelength

(c) increasing the slit separation **(d)** decreasing the slit separation.

(e) increasing the slit width **(f)** decreasing the slit width

$d\sin\theta = m\lambda$

$\sin\theta = \frac{m\lambda}{d}$

To decrease θ, decrease λ or increase d.

(D) In lecture, I sometimes use a projector. When I do, the image you see on the screen is…

(a) virtual.

(b) real.

(c) virtual if at least one of the optical components used in the projector is a negative lens.

(d) impossible to determine without knowing the optics used to create the image.