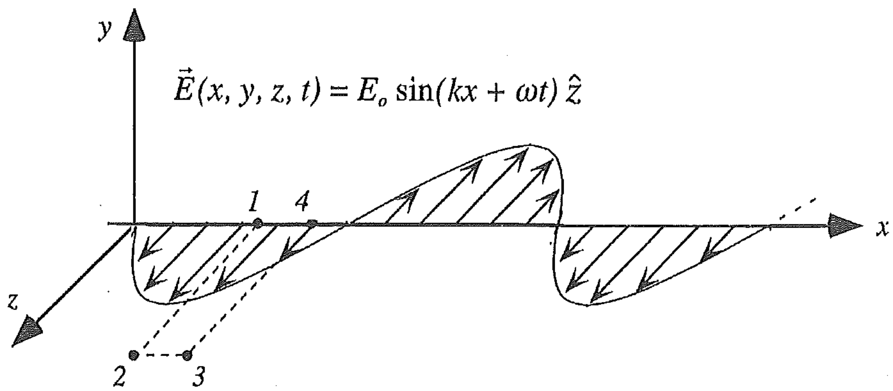
Physics 262 Midterm Exam 1 2013 Name SOLUTIONS

19 scantron questions & 2 ray tracing. $n_{water} = 1.333$

Move quickly through the easy questions; I recommend skipping Q19 on first time through.

The diagram shows the electric field at time t=0 for a sinusoidal plane EM wave in vacuum.



1. What direction is the wave moving?
a) +x b) –x c) +y d) –y e) +z f) –z g) a different direction h) not enough info

2. What is the direction of the **magnetic** field at point 1?
a) +x b) –x c) +y d) –y e) +z f) –z g) a different direction h) B=0 at point 1

3. Rank the magnitudes of the electric field at points 1 & 2
a) $E_1 = E_2$
b) $E_1 > E_2$ but $E_2 \neq 0$
c) $E_1 > E_2$ and $E_2 = 0$
d) cannot determine field at point 2

4. If this wave has a wavelength of 2 meters, it is:
a) x-ray b) visible c) near IR d) radio wave

5. For a wavelength of 2 meters, what is *k*, to the nearest m^{-1} ?
(Choose 0 -9, choose 9 for anything > 9.)

$k = \frac{2\pi}{\lambda} \approx 3$

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6. A special plastic has n = 1.233. A plano-convex lens is made with the convex side having a curvature radius of 0.4 m. What is the magnitude of the focal length *if this lens is used underwater?* Answer to the nearest meter. (Use 9 for anything > 9.)

$\frac{1}{f} = (n_e - n_s)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$= -0.1\left(\frac{1}{0.4}\right)$

$f = -4$ m.

7. What kind of lens is it (underwater), and what is the sign of the focal length?
a) converging, f > 0
b) converging, f < 0
c) diverging, f > 0
d) diverging, f < 0

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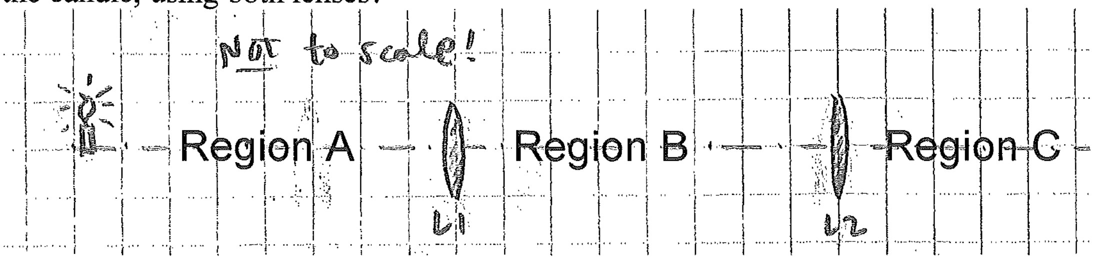
8. Two lenses, each of focal length +10 cm, are placed 15 cm apart. The first (left) lens, by itself, would form an image of a candle at s' = +30 cm. In which region on the diagram is the image of the candle, using both lenses?

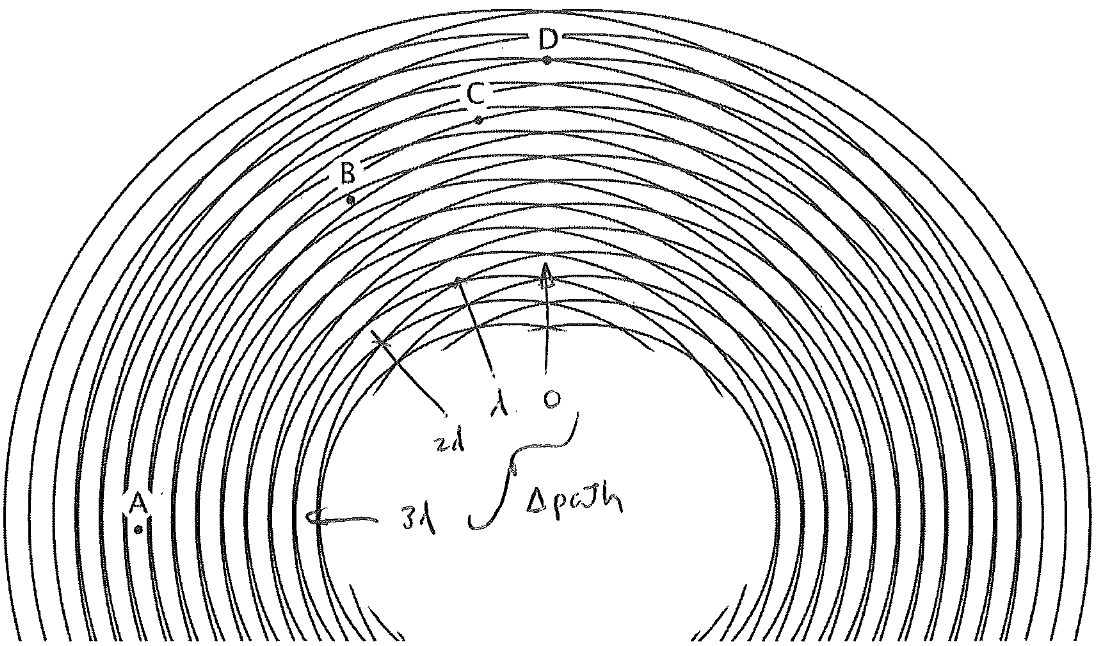


9. How far is the image from the right lens, to the nearest cm (use 9 for 9 or farther)?

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$\frac{1}{-15} + \frac{1}{s'} = \frac{1}{10}$$ ← $s = -15$ cm because it's a virtual object, 15 cm right of L2.

$$\frac{1}{s'} = \frac{1}{10} + \frac{1}{15} = \frac{3}{30} + \frac{2}{30} = \frac{5}{30}$$ $s' = 6$ cm. In Region C.



10. The cartoon above shows the wave crests for two sources, horizontally separated, emitting in phase. Where is there *destructive* interference?

a) only at A b) only at B c) only at C d) only at D e) at B&C
f) at A,B&C g) at B,C&D h) at all i) at none

11. What is the approximate separation of the sources, in terms of the wavelength?

a) 0 b) λ/2 c) λ d) 3λ/2 e) 2λ
f) 5λ/2 g) 3λ h) 7λ/2 i) 4λ j) >5λ

12. Two flat glass plates form a wedge-shaped gap which is filled with ooze from a jellyfish (technically, jellyfish are now called "jellies.") The sandwich is normally illuminated with green light ($\lambda_0 = 500$ nm, wavelength in vacuum.) The index of refraction of ooze is n_o. The difference in thickness of ooze between successive dark reflected fringes is: 1 wavelength path diff

a) $\lambda_0/2$ b) $n_o\lambda_0/2$ c) $\lambda_0/(2n_o)$ d) λ_0 e) $n_o\lambda_0$ f) λ_0/n_o $2t = \frac{\lambda_0}{n}$
g) the answer depends on whether ooze has a higher or lower index than glass

$t = \frac{\lambda_0}{2n}$

13. Where the glass plates come into contact, the ooze approaches zero thickness. In reflection, we should see: phase shift
a) a dark fringe b) a bright fringe c) an intensity halfway between bright & dark
d) the answer depends on whether ooze has a higher or lower index than glass

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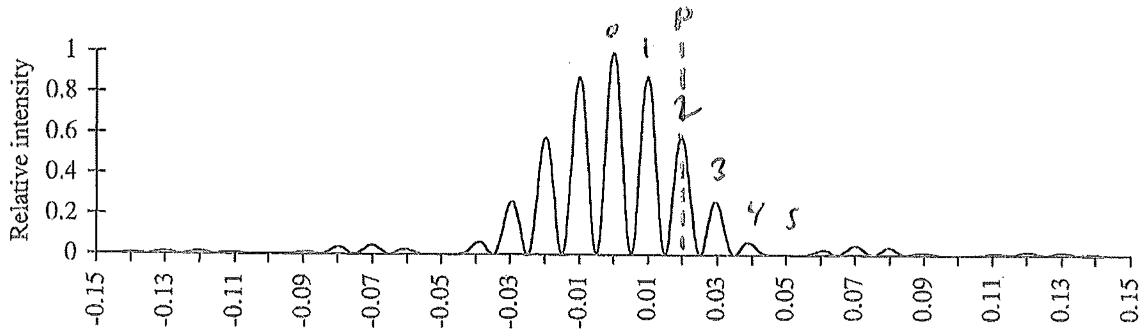


14. The two-slit interference/diffraction pattern above was made with UV light with wavelength 60 nm. What is the slit separation, in microns, to the nearest micron?

$d\sin\theta = \lambda \approx d\theta \qquad d = \frac{\lambda}{\theta} = \frac{60\text{ nm}}{0.01} = 6\,\mu m$

15. What is the slit width, in microns, to the nearest micron?

Missing order $= 5 \qquad \frac{d}{a} = 5 \qquad a = 1.2\,\mu m \approx 1\,\mu m$

16. If one slit is covered, what happens to the intensity at point P?
a) it is unchanged
b) it decreases to 0.5 on the relative intensity scale shown
c) it decreases by a factor of two (to about 0.3 on the relative intensity scale shown)
d) it decreases by a factor of $2\sqrt{2}$ (to 0.212)
e) it decreases by a factor of four (to 0.15) Amplitude is halved.

17. Two very narrow slits (i.e. ignore diffraction) are separated by 124λ. They are normally illuminated by a plane wave. Consider a point on a distant screen where the phase difference between waves from the two slits is 3π/2. What angle is this from the central maximum? Answer in milliradians, (10^{-3} radians) to the nearest milliradian. (Use 9 for >9 mrad.)

$$\frac{\Delta\varphi}{2\pi} = \frac{\Delta path}{\lambda} \qquad \Delta path = \frac{3\pi}{2}\cdot\frac{\lambda}{2\pi} = \frac{3}{4}\lambda = d\sin\theta$$

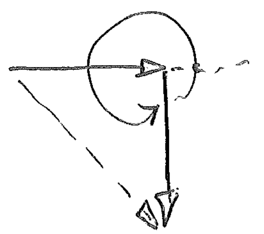
$$\approx 124\lambda\cdot\theta$$

$$\theta = \frac{3/4}{124}\ \text{rad} = 6\ \text{mRad.}$$

18. What is the ratio of the intensity at the central maximum to the intensity at this point (where the phase difference is 3π/2) ? (Give the nearest multiple, use 0 if this point is brighter than the central maximum, 9 for 9 or greater.)

Phasors.

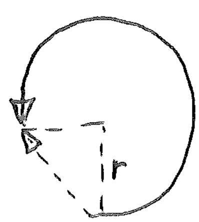
3π/2.



$$\frac{E_c}{E} = \frac{2}{\sqrt{2}} \quad \text{so} \quad \frac{I_c}{I} = \frac{4}{2} = 2.$$

19. If the space between the slits is removed, you will have a single slit of width 124λ. What is the new ratio of the intensity at the new central maximum to the intensity at this same point on the screen? (Give the nearest multiple, use 0 if this point is brighter than the central maximum, 9 for 9 or greater.)

Phasor diagram



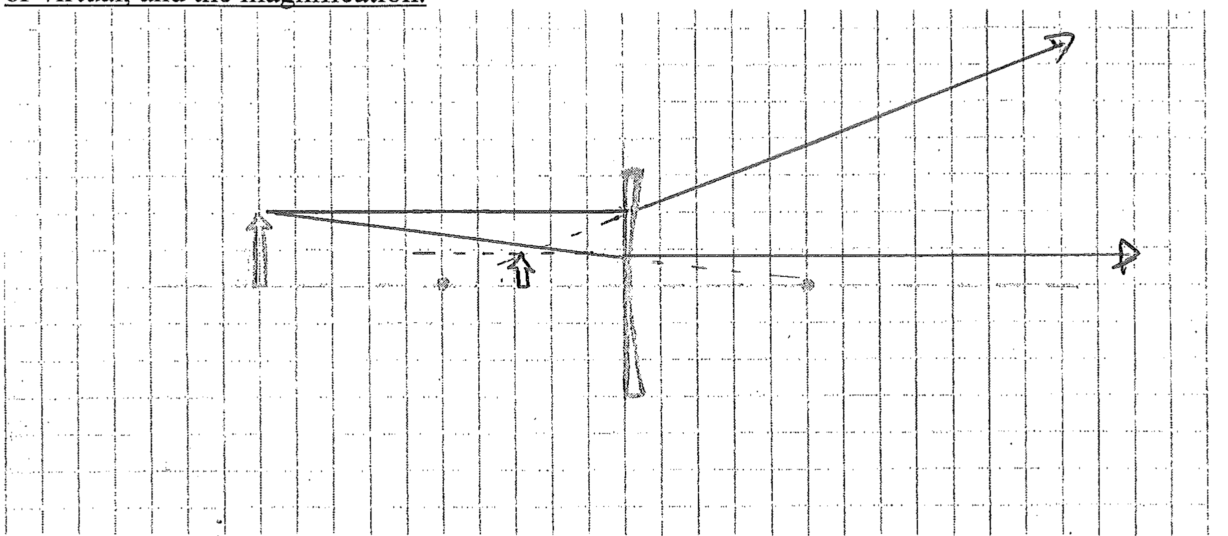
$$\frac{E_c}{E} = \frac{\frac{3}{4}\cdot 2\pi r}{\sqrt{2}\, r}$$

so

$$\frac{I_c}{I} = \frac{9\pi^2}{8} = 11.1$$

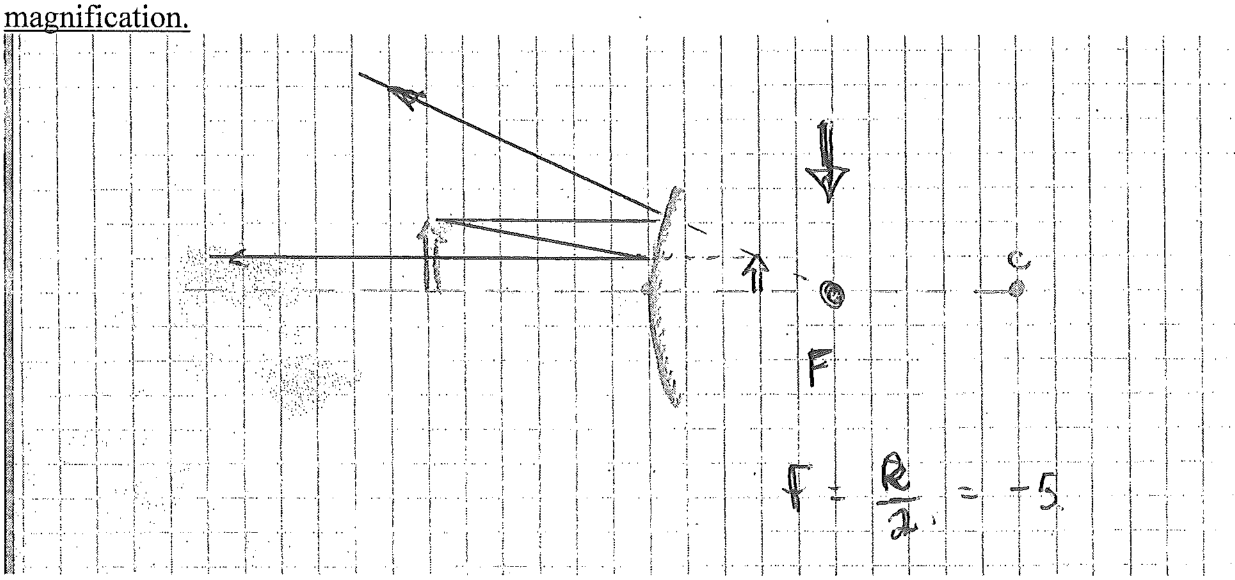
bubble 9

20 (3 pts). Ray trace from the tip of the arrow through the *diverging* lens shown to find the image. Draw two rays that make use of the focal points shown. Indicate whether the image is real or virtual, and the magnification.



Virtual $m \approx \frac{3}{10}$.

21 (3 pts). Ray trace from the tip of the arrow for the convex mirror shown. Draw two rays that make use of the focal point (or points if there is more than one). The center of the mirror curvature is shown as point C. Indicate whether the image is real or virtual, and the magnification.



Virtual $m = \frac{3}{10}$.