1.	2.	3.	Total
38	20	24	82

good

Physics 1CH Midterm #1 April 27, 2017

On all problems, you need to show your work to get full credit.

Below are a set of numerical constants. If you have any questions, please raise your hand to ask for help.

Acceleration of gravity (Earth)	g	10.0 m/s^2
Boltzmann constant	k	1.38 x 10^{-23} J/K
Electron charge	e	1.60 x 10^{-19} C
Electron mass	m_e	9.11 x 10^{-31} kg
		0.511 MeV/c^2
Electron-volt	eV	1.60 x 10^{-19} J
Permeability of free space	μ_o	4π x 10^{-7} N/A^2
Permittivity of free space	ε_o	8.85 x 10^{-12} C^2/N-m^2
Planck constant	h	6.63 x 10^{-34} J-s
Proton mass	m_p	1.67 x 10^{-27} kg
		938 MeV/c^2
Speed of light in vacuum	c	3.00 x 10^8 m/s
Speed of sound in air (20° C)	v_s	340 m/s

Small angle approximation (θ in radians):

$$\sin(\theta) \approx \tan(\theta) \approx \theta$$

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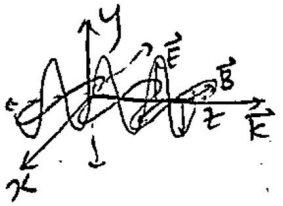
Problem 1: Short Answer (40 points total):

a) True or False. In an electromagnetic wave in a vacuum, the electric and magnetic fields are in phase and the electric and magnetic field vectors, $\vec{E}$ and $\vec{B}$, are equal in magnitude. Explain your answer.

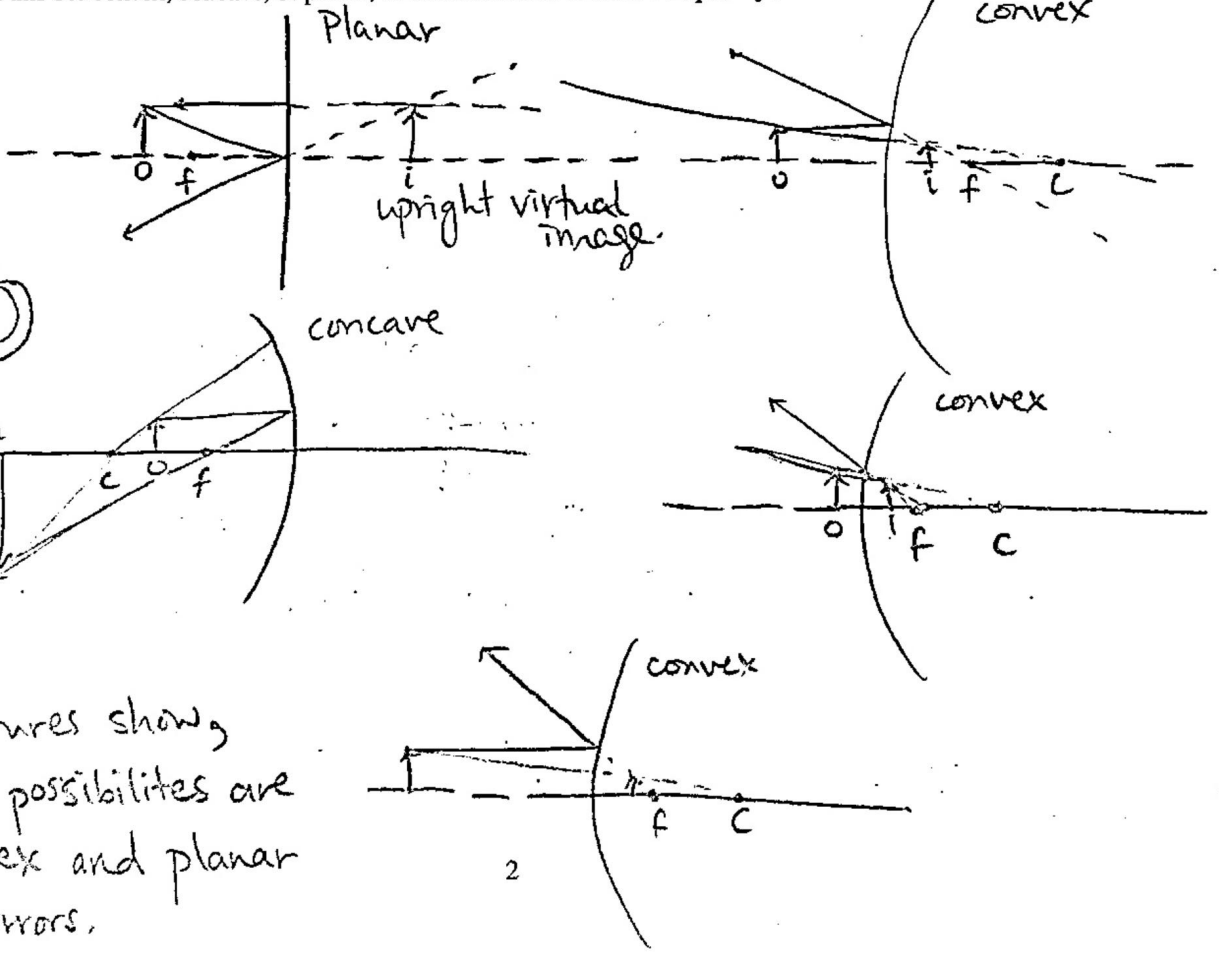
False; the magnitudes of the electric ($\vec{E}$) and magnetic ($\vec{B}$) fields are not equal. In vacuum, their magnitudes are related in the form:- $E = cB$. Both the $\vec{E}$ & $\vec{B}$ are in-phase though :-(shown below) (because $\vec{E}$ & $\vec{B}$ move together).

If $\vec{E}$ is in $\hat{z}$, $\vec{E}$ in $\hat{y}$, and $\vec{B}$ in $\hat{x}$

10



b) No matter where you stand in front of a certain mirror, your image appears upright. What type of mirror could this be: convex, concave, or planer, or more than one of these? Explain your answer.

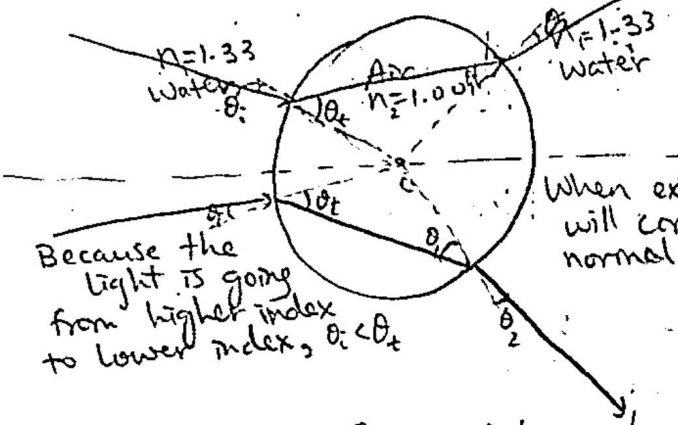


As the pictures show, the 2 possibilites are convex and planar mirrors.

Problem 1 (continued):

c) Light shines through a spherical air bubble that is under water. What type of optical device does the bubble act like: converging, diverging, or planar? Explain your reasoning (there are several different ways to explain this and a good figure would really help).

The bubble will act like a diverging lens.



Good

So, as picture shows, the bubble acts like a diverging lens (since light transmits through).

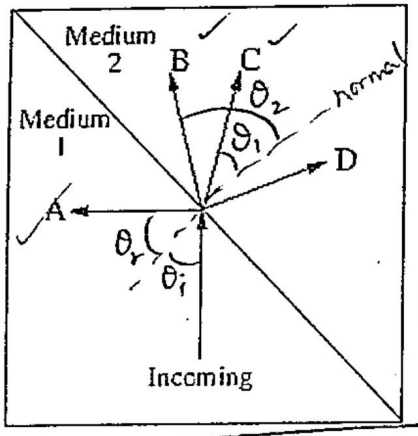
10

d) For the diagram below, showing a light ray approaching a boundary between two transparent media, which of the outgoing rays (A, B, C, D) could *not* result from the incoming ray? Explain your answer (it may be useful to say why the allowed rays are allowed).

① A is allowed because that is a reflected ray (with $\theta_i = \theta_r$ = in picture)
-Not all rays have to transmit completely; they can reflect and transmit.

② If medium 1's index of refraction is larger than medium 2's index, then $\theta_i < \theta_t$, so B is acceptable.

③ If medium 1's index < medium 2's index ($\theta_i > \theta_t$), then C is acceptable



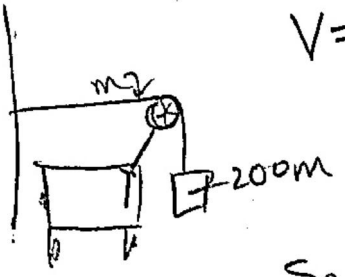
So, D is not possible. ↑ but explain why?

8

Problem 2: String Theory (30 points total) $\rho = \frac{m}{L}$ $v = \sqrt{T/\rho}$

A long horizontal string of uniform mass density is put under tension by tying one end of the string to a wall and passing the other end over a pully and attaching it to a metal weight that has 200 times the mass of the string. It takes 0.05 s for a pulse to propagate from one end of the string to the other.

a) What is the length, L, of the string? You can assume that the amount of string going around the pulley is neglgible and ignore any sag or deflection in the string due to gravity.



$v = \frac{d}{t} = \frac{L}{0.05\,sec}$

$v = \sqrt{T/\rho}$

So, $\sqrt{\frac{T}{\rho}} = \frac{L}{0.05\,sec}$

$\boxed{L = 0.05\sqrt{T/\rho}}$ with ρ = mass density. T = Tension.

$\rho = \frac{m}{L}$

$\rho L = m$

$T = (200\rho L)g$

So, $L = 0.05\sqrt{\frac{(200\rho L)g}{\rho}}$

10

Yes now solve!

$L = 0.05(200Lg)^{1/2}$

b) A transverse harmonic wave is imposed on the string with an amplitude, $A = 0.2$ m, and a wavelength, $\lambda = L/10$. Assume that the wave moves in the $+x$ direction and is described by a trigonometric function (i.e. sine or cosine or a combination of both). Write down the equation for the wave, $y(x,t)$, subject to the initial conditions that $y(0,0) = 0.2$ m and $\dot{y}(0,0) = 0$ m/s. Substitute numbers for all known quantities. What is the wavelength and frequency of the wave?

1 $y(x,t) = A\cos(kx - \omega t) + \phi$ $k = \frac{2\pi}{\lambda} = \frac{2\pi}{L/10} = \frac{20\pi}{L}$

2 $y(x,t) = 0.2\cos\left(\frac{20\pi}{L}x - \omega t\right)$ Why cosine

$\boxed{y(x,t) = 0.2\cos\frac{20\pi}{L}\left(x - (\sqrt{200Lg})t\right)\,m}$

10

$\lambda = L/10$ m 2

wavelength $\omega = 2\pi v$

$\omega = \frac{20\pi}{L}\left(\sqrt{200Lg}\right)$ 1

$\omega = 2\pi f \Rightarrow f = \frac{20\pi\sqrt{200Lg}}{L\,2\pi} = \boxed{\frac{10}{L}\sqrt{200Lg}\ Hz}$ 4

Problem 2 (continued)

c) As the wave passes by a particular fixed point, what is the maximum *transverse* speed of a point on the string? At a fixed pt., the waves makes the particle on the string move up and down a distance of (0.2)2 meters. It takes the pulse 0.05 sec. So, $\frac{0.4}{0.05} = 8\ m/s$.

↓

Need force interactions

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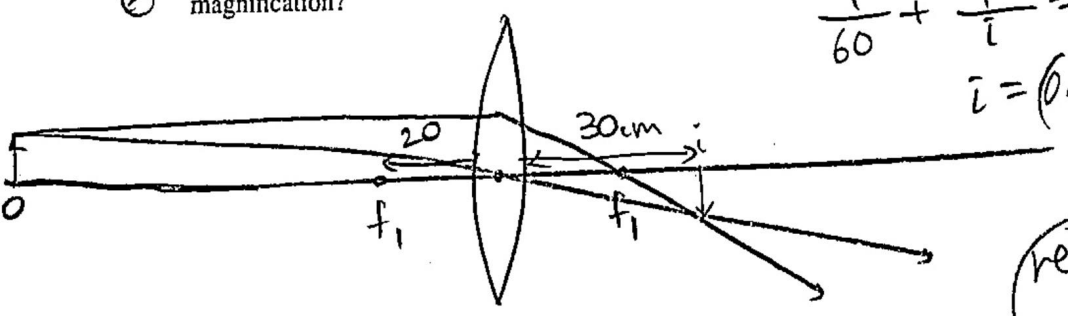
Problem 3: Objects and Images (30 points total)

On an optical bench is a lens with focal length, $f_1 = +20\,\text{cm}$, and a mirror of unknown type (convex, concave, or planar) and unknown focal length. An object, O_1, is located 60 cm to the left of the lens. The mirror is located 40 cm to the right of the lens. The image formed by the mirror, I_2, is inverted and is the same size when compared to the original object O_1.

6 a) Determine the position of the image formed by the lens, I_1. Is it real/virtual, upright/inverted, and what is its magnification?



$\frac{1}{60} + \frac{1}{i} = \frac{1}{20}$ +1

$i = (0.05 - 0.0166)^{-1} = 30\text{cm}$ +1

right of lens +1

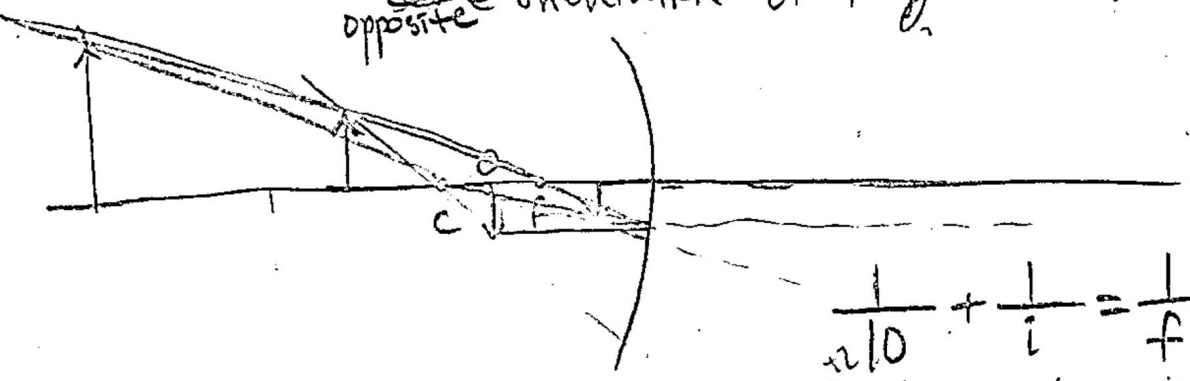
real, inverted image +1 +1

$m = \frac{-i}{O} = \frac{-30}{60} = -\frac{1}{2}$ +1

$-\frac{1}{2} = m$

9 b) Given what you know about the second image, determine the properties of the mirror: is it convex, concave or planer (or is it ambiguous) and what is its focal length? Determine the position of the image formed by the mirror, I_2. Is it real/virtual?

The image is virtual +1. The mirror has to be concave +1 because it can magnify/demagnify and get the opposite orientation of image of object.



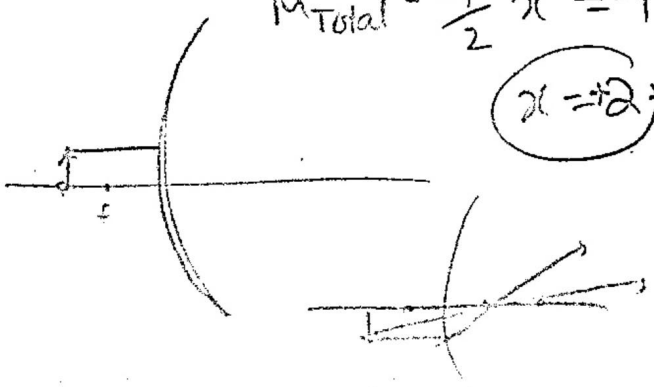
$\frac{1}{+10} + \frac{1}{i} = \frac{1}{f}$ +1

$\frac{1}{10} + \frac{1}{-20} = \frac{1}{f}$

$f = +20\,\text{cm}$ +1

$M_{Total} = -\frac{1}{2} \times -1$

$\times = +2$ +2 => magnification of image due to mirror.



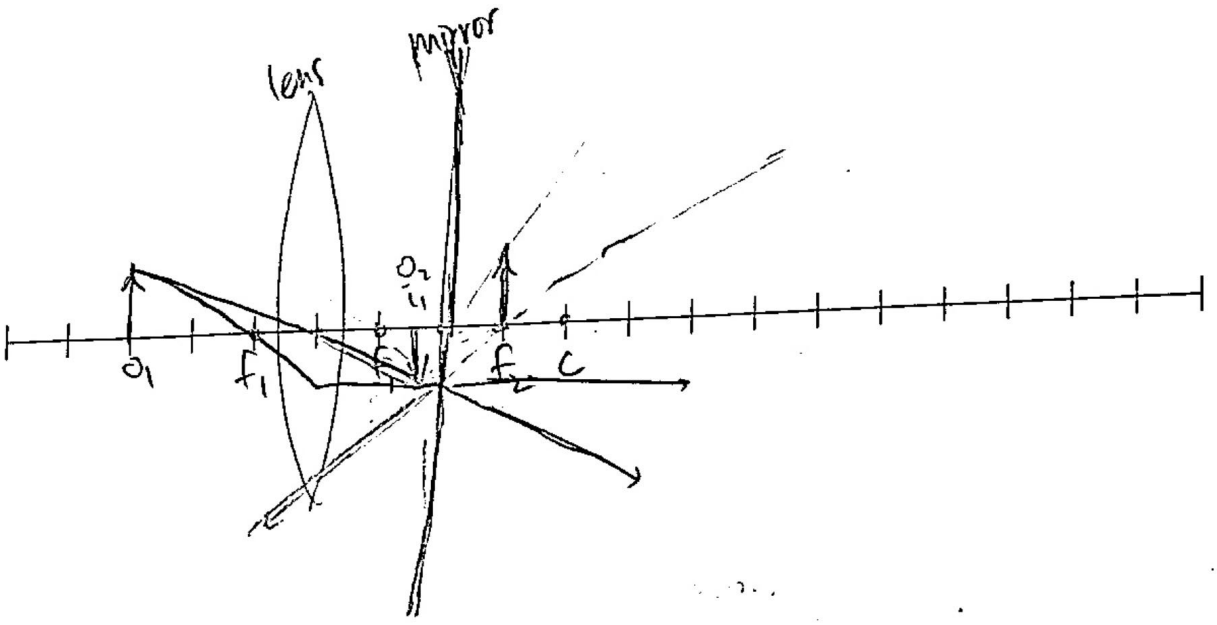
$m = \frac{-i}{O} = \frac{-i}{10} = 2$ +1 direction?

$i = -20$ cm ← position of image

Problem 3 (continued)

9

c) On the horizontal axis below, draw the lens and the mirror. Then, provide a ray-trace for at least two rays from the initial object to the first image and then at least two rays from the second object to the second image. Indicate the positions of O_1, I_1, O_2, I_2, F_1, F_2, and C, where F_1 identifies the focal points of the lens, F_2 identifies the focal point of the mirror and C identifies the center of the mirror. (You do not have to ray-trace back through the lens to form a third image).



+1 O_1
+1 lens
+1 mirror
+2 F_1
X C
X F_2
+2 Ray 1
+1 I_1
+1 O_2
X Ray 2
X I_2