Instructor(s): *P. Hirschfeld*

PHYSICS DEPARTMENT

PHY 2005, Spring 2017 EXAM III April 10, 2017

Name (print, last first): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

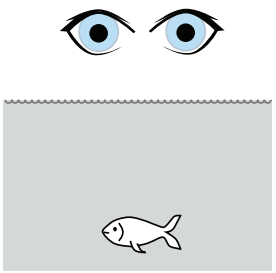
YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

(1) **Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number)**. Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY**. Code your UFID number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. **Circle your answers on the test form.** At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.
(4) **Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink**. Do not make any stray marks or some answers may be counted as incorrect.
(5) **The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.**
(6) Hand in the answer sheet separately.

Physical Constants:

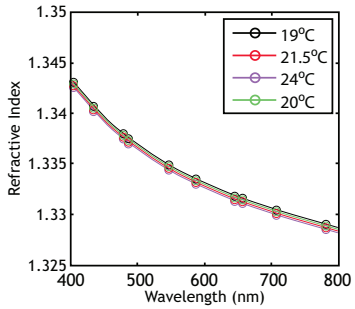
$g = 9.8$ m/s^2	$m_e = 9.11 \times 10^{-31}$ Kg	$m_p = 1.67 \times 10^{-27}$ Kg
$\mu_o = 4\pi \times 10^{-7}$ T·m/A	$e = 1.6 \times 10^{-19}$ C	$\varepsilon_o = 8.85 \times 10^{-12}$ C^2/Nm^2
Speed of light in vacuum $c = 2.998 \times 10^8$ m/s	constant k in Coulomb's Law: $k = 8.99 \times 10^9$ Nm^2/C^2	

1. A fish swims below the surface of the water. Suppose an observer is looking at the fish straight above the fish. The observer sees



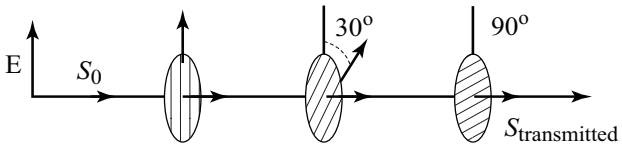
(1) the fish at a shallower depth than it really is.
(2) the fish at its actual depth.
(3) the fish at a greater depth than it really is.
(4) no fish due to total internal reflection.
(5) no fish due to dispersion.

2. Yellow light has a wavelength 589 nm. What is the speed of the light in a medium with an index of refraction that changes with wavelength as shown in the figure?



(1) 2.25×10^8 m/s
(2) 4.01×10^8 m/s
(3) 3.00×10^8 m/s
(4) 2.29×10^8 m/s
(5) 2.21×10^8 m/s

3. A linearly polarized beam of light is incident upon a group of three polarizing sheets. The first polarizer is oriented along the electric field of the incident light beam. The second is rotated by 30° with respect to the first sheet, as shown. The third is rotated by 90° with respect to the first polarizer. What fraction of the incident intensity is transmitted through to the other side of the three polarizers?



(1) 3/16 (2) 1/4 (3) 1/8 (4) 3/4 (5) 1/2

4. Which one of the following statements concerning electromagnetic waves is false?

   (1) Electromagnetic waves are longitudinal waves.
   (2) Electromagnetic waves transfer energy through space.
   (3) The existence of electromagnetic waves was predicted by Maxwell.
   (4) Electromagnetic waves can propagate through a material substance.
   (5) Electromagnetic waves do not require a physical medium for propagation.

5. It is desired to use a 60-cm focal length diverging lens to form a virtual image of an object. The image is to be one-third as large as the object. Where should the object be placed and what will be the image distance in cm?

   (1) (120, −40) (2) (−165, −45.2) (3) (55, −22.5) (4) (−155, 41.3) (5) (55, 22.5)

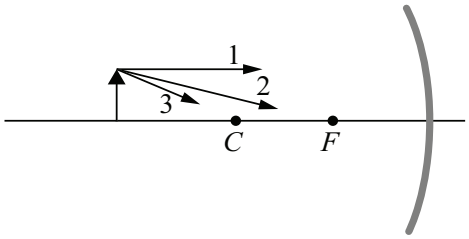
6. The yellow light from a sodium lamp has a wavelength of 589 nm in vacuum. When this light is propagating through mineral oil with an index of refraction $n = 1.52$, what is its wavelength in nm?

   (1) 387.5 (2) 895 (3) 589 (4) 439.7 (5) 282

7. A concave mirror has a 30 cm radius of curvature. If an object is placed 10 cm from the mirror, at what distance q from the mirror will the image be found, and is it magnified or reduced?

   (1) (−30 cm ; magnified)
   (2) (15 cm ; reduced)
   (3) (−15 cm ; magnified)
   (4) (30 cm ; reduced)
   (5) (20 cm ; neither reduced nor magnified)

8. An object is placed in front of a concave spherical mirror as shown. The three rays **1**, **2**, and **3**, leave the top of the object and, after reflection, converge at a point on the top of the image. Ray **1** is parallel to the principal axis, ray 2 passes through F (focal point), and ray **3** passes through C (center of sphere). Answer this problem and the following one.

   Which ray will pass F after reflection and which ray will reflect back on itself (pass F : reflect back)?

   (1) (1 : 3) (2) (2 : 1) (3) (1 : 2) (4) (1,2 : 3) (5) (1 : 2,3)

9. Two microwave emitters send out identical sound waves along the x axis. The wavelength of the waves is 90 cm. One emitter is at $x = 0$. An observer with a microwave detector is far away. The other emitter starts at $x = 0$ and is moved to positions along the x axis to the right. At what 2nd emitter positions between $0 < x < 2$m will the observer detect the maximum microwave intensity? (Assume both emitters are always in phase: they emit crests at the same instant.)

   (1) 0.0m, 0.9m; 1.8m (2) 0.0m, 0.45m,0.9m,1.35m,1.8m (3) only at 0.0m (4) 0.45m, 1.35m (5) only at 2.0m

10. A woman stands 2.0 m in front of a convex mirror and notices that her image height is 1/4 of her actual height. Determine the radius of curvature of the mirror. (in m)

    (1) 1.3 (2) 0.67 (3) 2.0 (4) 6.0 (5) 4.0

11. Two lenses are both converging, and each has a 25-cm focal length. They are placed 50 cm apart with their optical axes aligned each other. A 3-cm tall object is placed 75 cm in front of the first lens. Find the final image position relative to the second lens and its size (in cm).

    (1) −25, 3 (2) −40, 1 (3) −32, 6 (4) 40, 3 (5) −50, 6

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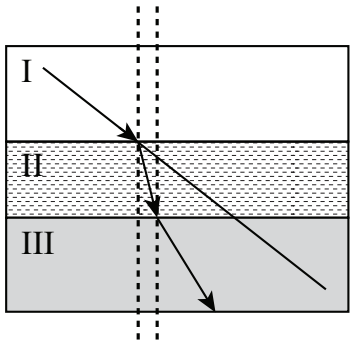
12. As a beam goes through layers of different materials (I, II, and III), it bends as shown in the figure. The angles in the figure indicate the angle between each beam and the vertical line. Those materials and their index of refraction are listed in the table. Identify each material (material I, material II, material III).

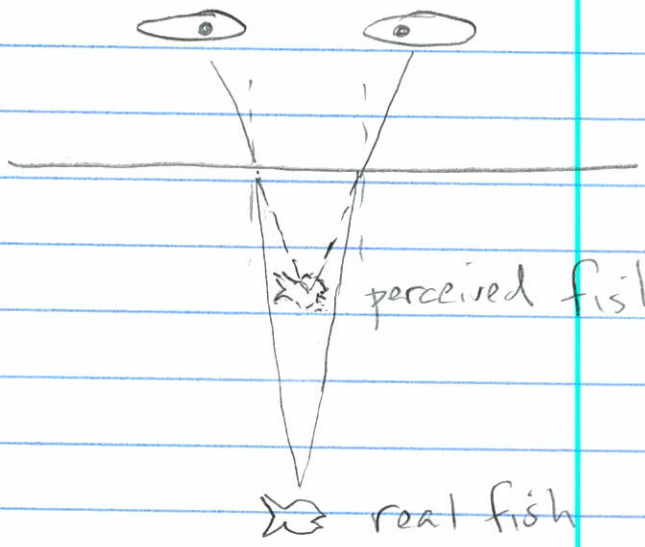
Material	Index of Refraction (n)
air	1.00
ice	1.31
diamond	2.42



(1) (air, diamond, ice) (2) (diamond, ice, air) (3) (diamond, air, ice) (4) (air, ice, diamond) (5) (ice, diamond, air)

PHY 2005 Exam III S'17 Solutions

1) Draw rays that reach the 2 eyes, + extend into water to see depth at which fish is perceived:



2) Reading from graph, 589 nm light has $n \cong 1.333$. Speed of light in medium is $c/n = 3.000/1.333 \times 10^8 \text{ m/s}$

$= 2.25 \times 10^8 \text{ m/s}$

EC 3) 1st polarizer passes 100% of incoming intensity, since polarization axis is aligned with $\vec{E}$-field. 2nd polarizer passes $\cos^2 30^\circ = \frac{3}{4}$ of the intensity. Now $\vec{E}$-field is polarized along 2nd polarizer's direction. The angle between it and 3rd polarizer

is now 60°, So 3rd polarizer reduces intensity by $\cos^2 60° = \frac{1}{4}$, Total reduction is

$$S = \frac{3}{4}\cdot\frac{1}{4} S_0 = \frac{3}{16} S_0$$

4) All statements are correct except that EM waves are longitudinal. EM waves are oscillations in $\vec{E}, \vec{B}$ which are both transverse to propagation direction of the wave.

5) $f = -60$, diverging, $M = \frac{f_i}{f_o} = \boxed{\frac{1}{3} = \frac{-q}{p}}$

$q < 0$ since image is virtual

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{p} - \frac{3}{p} = \frac{-2}{p} = \frac{-1}{60}$$

$$\Rightarrow \boxed{p = 120 \quad q = -40}$$

6) Light traveling in a medium has a reduced wavelength $\lambda = (\lambda \text{ in vacuum})/n$

$$\lambda = 589 \text{ nm} / 1.52 = 387.5$$

7) $R = 30 \quad f = R/2 = 15$

$p = 10$

$$\frac{1}{f} = \frac{1}{q} + \frac{1}{p} = \frac{1}{q} + \frac{1}{10} = \frac{1}{15}$$

$$\frac{1}{q} = \frac{1}{15} - \frac{1}{10} = \frac{2}{30} - \frac{3}{30} = -\frac{1}{30}$$

$$q = -30 \qquad M = \frac{-q}{p} = \frac{30}{10} = 3$$

8) Ray 1 comes in // to optical axis, so it is reflected through the focal point. Ray 3 passes through the center of the mirror, so it is reflected directly back.

9) Constructive interference $\Rightarrow$ path difference

$$\Delta x = n\lambda$$

$n = 0, 1, 2 \Rightarrow \Delta x = 0, 90\,cm, 180\,cm$

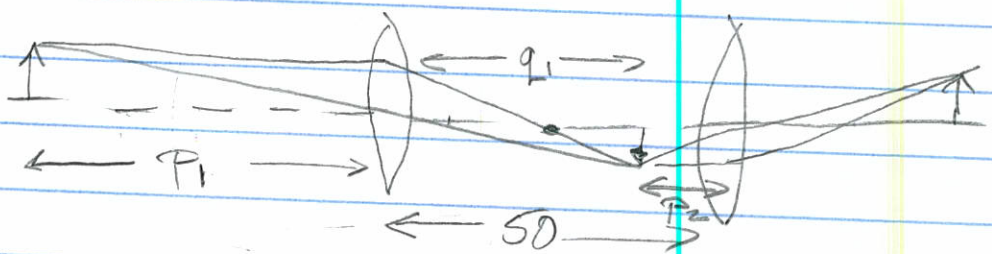
10) $p = 2m \qquad M = \frac{-q}{p} = \frac{-q}{2} = \frac{1}{4}$

$$\Rightarrow q = -\frac{1}{2}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{2} + \frac{1}{(-2)} = \frac{1}{f} = \frac{2}{R}$$

$$\frac{3}{2} = \frac{2}{R} \Rightarrow R = \frac{4}{3}$$

11)



$$\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{75} + \frac{1}{q_1} = \frac{1}{25}$$

$$\frac{1}{q_1} = \frac{1}{25} - \frac{1}{75} = \frac{2}{75} \qquad q_1 = 37.5$$

$$p_2 = 50 - 37.5 = 12.5$$

$$\frac{1}{q_2} + \frac{1}{12.5} = \frac{1}{25}$$

$$\Rightarrow \frac{1}{q_2} = \frac{1}{25} - \frac{2}{25} = \frac{-1}{25}$$

$$\Rightarrow q_2 = -25$$

$$M = \left(\frac{-q_1}{p_1}\right)\left(\frac{-q_2}{p_2}\right) = \left(\frac{37.5}{75}\right)\left(\frac{25}{12.5}\right) = 1$$

image height is same as original object 3

12) When ray hits interface of denser medium, it bends closer to normal

I - II closer => II denser than I

II - III further away => II denser than III

only air diamond ice and ice diamond air

But change of angle is bigger at I - II
hence index of refraction change is
bigger => must be air - diamond.