Physics 228 - First Common Hour Exam
February 19, 2006
Prof. Coleman and Dr. Francis

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Your name sticker with **exam code**
$\Longrightarrow$

Your signature ______________________________

Turn off and put away cell phones now!

1. The exam will last from 3:00 PM to 4:20 PM. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit student ID.
4. Enter 227 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
7. There are 15 multiple-choice questions on the exam. Mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. **At the end of the exam, hand in the answer sheet and the cover page.** Retain this question paper for future reference and study.
8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

Some possibly useful information:
c = speed of light = 3.00×10^8 m/s
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
1 mHz = 10^{-3} Hz   1 kHz = 10^{+3} Hz
1 MHz = 10^{+6} Hz   1 GHz = 10^{+9} Hz
1 nm = 10^{-9} m   1 Å = 10^{-10} m = 0.1 nm
$\cos(\alpha \pm \beta) = \cos(\alpha)\cos\beta \mp \sin(\alpha)\sin(\beta)$
$\sin(\alpha \pm \beta) = \sin(\alpha)\cos(\beta) \pm \cos(\alpha)\sin(\beta)$

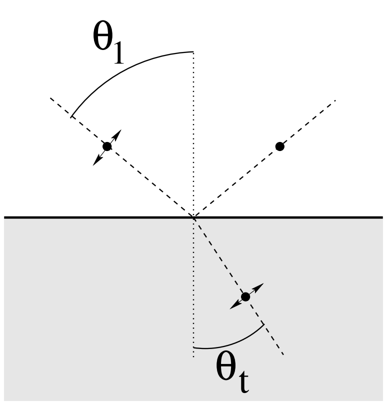
1. The *thinnest* film of oil (n=1.50) floating on water (n=1.33) that would give maximum reflection of red light (λ_0=680 nm) is

   a) 227 nm
   b) 113 nm
   c) 170 nm
   d) 256 nm
   e) 128 nm

2. A radio station operating at frequency 99.5 MHz broadcasts from two towers. What is the farthest distance the towers can be apart to make sure there are no "dead zones", places where the radio signal is completely canceled out by destructive interference?

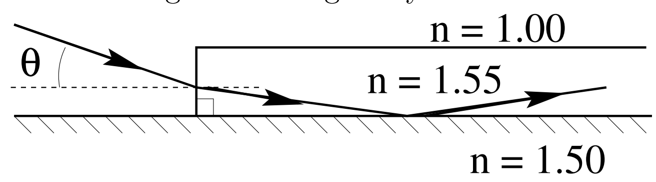
   a) 3.0 m b) 1500 km c) 0.17 m d) 0 m
   e) 1.5 m

3. An unpolarized beam of light is incident in air onto the surface of a flat glass slab (n = 1.5). The reflected light is completely plane polarized. What is the angle of refraction (θ_t) for the light transmitted into the glass?



   a) 90°
   b) 28.1°
   c) 45°
   d) 33.7°
   e) 21.7°

4. A thin film of index $n = 1.55$ deposited on a glass slide ($n = 1.50$), as shown, is to be used as an optical waveguide. To operate properly, total internal reflection must occur at both the film-air and the film-glass interfaces. What is the maximum entrance angle θ that light ray can have for this to work?



   a) 75° b) 23° c) 35° d) 47° e) 14.5°

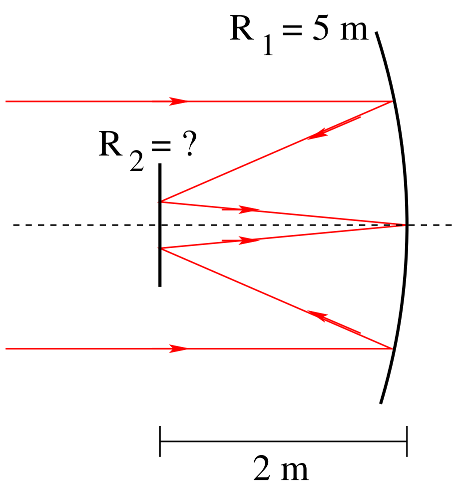
5. A concave mirror has focal length $f > 0$. A real object is placed a distance $2f$ from the mirror. Then the image is

   a) Real; inverted; same size as object
   b) Real; inverted; smaller
   c) Virtual; upright; bigger
   d) Virtual; upright; smaller
   e) Real; inverted; bigger

6. An polarized beam of light is incident on a group of two polarizing sheets that are lined up so that the polarizing axis of the first sheet is rotated by 30° with respect to the polarization of the incident light, and the polarizing axis of the second sheet is rotated by 30° with respect to the polarizing axis of the first sheet. What fraction of the incident *intensity* is transmitted?

   a) 9/16
   b) 3/4
   c) 27/64
   d) 1/4
   e) 2/3

7. Parallel light from a distant object ($s \approx \infty$) strikes a large concave mirror (radius $R_1 = 5.00$ m), reflects off a smaller mirror of unknown radius, and focuses on the vertex of the larger mirror. The centers of the mirrors are 2 meters apart. What is the radius of curvature of the smaller mirror, and is it concave or convex?



a) $R_2 = -1.33$ m, mirror is convex
b) $R_2 = -2.00$ m, mirror is convex
c) $R_2 = -4.00$ m, mirror is convex
d) $R_2 = +4.00$ m, mirror is concave
e) $R_2 = -0.66$ m, mirror is convex

8. A lens made of glass of refractive index 1.6 is flat on one side, and convex, with curvature 40 cm on the other side. What is the focal length of this lens?

a) 33 cm   b) -67 cm   c) 67 cm
d) -25 cm   e) 25 cm

9. A beam of red light of wave length 7000 Å shines on a diffraction grating which has 5000 lines per cm. The central maximum occurs on a wide, distant wall at $\theta = 0$. How many additional maxima can be observed on the wall for θ positive?

a) four
b) two
c) three
d) none
e) one

10. The Rutgers radio telescope (on the roof of the physics building) is a dish 2.3 meters in diameter. If the light falling on it has a wavelength of 21 cm, what is the smallest angle the dish can see on the sky? (Hint: treat the dish like a circular aperture.)

a) 5.2°
b) 0.11°
c) cannot solve the problem with the information given
d) 6.4°
e) 9.1°

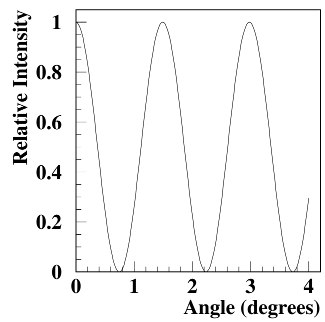
11. A fish is swimming 30 cm below the water surface, and an insect is flying 12 cm above the surface. If the index of refraction of water is 4/3, how far from the water surface will the fish see the insect's image? (Assume the line of sight makes a small angle to the normal).

a) 12 cm
b) 56 cm
c) 16 cm
d) 31.5 cm
e) 9 cm

12. A person 1.62 m tall wants to be able to see her full image in a flat mirror. What is the maximum height above the floor the bottom of the mirror be, assuming her eyes are 15.0 cm below the top of her head?

a) 1.62 m b) 0.735 m c) 0 m d) 0.150 m
e) 0.810 m

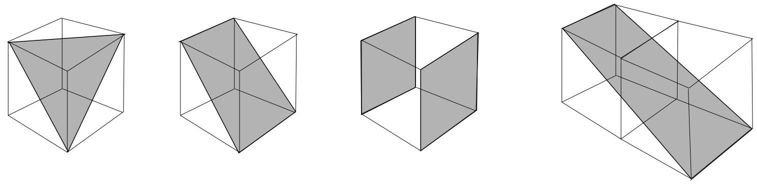
13. Light of wavelength 520 nm passes through a double slit, yielding the interference pattern of intensity I versus deflection angle θ shown. What is the separation, d, between the slits?



a) 5.0×10^{-2} mm
b) 1.1×10^{-2} mm
c) 2.0×10^{-2} mm
d) 6.7×10^{-3} mm
e) 4.5×10^{-3} mm

14. X-rays of wavelength 0.2 Å are diffracted off a crystal with a cubic unit cell side length $a = 1$ Å. One of the X-ray diffraction spots occurs when the beam makes an angle of 10 degrees to the planes. Which of the planes shown in the figure produces this reflection?

(I) $d = a/\sqrt{3}$ (II) $d = a/\sqrt{2}$ (III) $d = a$ (IV) $d = a/\sqrt{5}$



a) (II) b) (IV) c) (III)
d) none of the above e) (I)

15. A ray of light goes from air into water. Which of the following is true?

a) Its speed decreases
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b) Its frequency decreases
c) Its wavelength stays the same
d) Its speed stays the same
e) Its frequency increases