# Midterm 1

October $1^{st}$, 2013
*120minutes ⋄ 100points*

Physics 7C Fall 2013
University of California at Berkeley

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This midterm is closed book and closed notes. You are allowed one side of a sheet of paper on which you may write whatever you wish. You are not allowed to use calculators. Anyone who does use a wireless capable device will automatically receive a zero for this midterm. Cell phones must be turned off.

Please make sure that you do the following during the midterm:
- ⋄ Write your name, discussion number, ID number on all documents you hand in.
- ⋄ Make sure that the grader knows what s/he should grade by circling your final answer.
- ⋄ Cross out any parts of your solutions that you do not want the grader to grade.
- ⋄ Give all your numerical answers with one significant figure.

We will give partial credit on this midterm, so if you are not altogether certain how to do a problem, or if you do not have time to complete a problem, be sure to write down as much information as you can on the problem. This includes any or all of the following: drawing a clear diagram of the problem, telling us how you would do the problem if you had the time, telling us why you believe (in terms of physics) the answer you got to a problem is incorrect, and telling us how you would mathematically solve an equation or set of equations once the physics is given and the equations have been derived. Don't get too bogged down in the mathematics; we are looking to see how much physics you know, not how well you can solve math problems. If at any point in the exam you have any questions, just raise your hand, and we will see if we are able to answer them.

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PROBLEM 1 ◇ RADIO ANTENNAS ◇ *30points*

A 100MHz radio station is a point source antenna emitting average power of 400kW uniformly in all directions. You are using a circular loop of wire as a receiver for its electromagnetic waves.

- ◇ **A** ◇ *5points* ◇ What is the wavelength of the radio wave?
- ◇ **B** ◇ *5points* ◇ For maximum induced voltage in the loop should the normal to the plane of the loop be oriented parallel or perpendicular to the a line drawn between the antenna and the receiver?
- ◇ **C** ◇ *10points* ◇ What is the maximum rms voltage that could be induced in your receiver loop of radius 30cm at a distance of 100m from the station?
- ◇ **D** ◇ *10points* ◇ The radio station turns on another identical radio emitter positioned 9m from the first one in the direction perpendicular to the line drawn between the first station and your receiver. Do you hear a stronger or weaker signal as a consequence of the second antenna coherently emitting the same signal as the first.

You can use that the permittivity of air is close to that of vacuum $\epsilon_0 \approx 9 \times 10^{-12}\ C^2/N \cdot m^2$ and permeability of air is approximately $\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$ while speed of light in air is close to $c = 9 \times 10^{-8} m/s$.

PROBLEM 2 ◇ THIN FILM OF OIL ◇ *20points*

A thin film of oil with refractive index $n_{oil} = \frac{3}{2} = 1.5$ is floating on water with $n_{water} = \frac{4}{3} \approx 1.33$.

- ◇ **A** ◇ *5points* ◇ What is the thinnest film of oil that would give maximum reflection of red light with wavelength $\lambda_R = 700$nm at normal incidence?
- ◇ **B** ◇ *5points* ◇ What is the thinnest film of oil that would give maximum reflection of violet light with wavelength $\lambda_V = 420$nm at normal incidence?
- ◇ **C** ◇ *5points* ◇ What is the thinnest film of oil that would give maximum reflection of light for both of these wavelengths when illuminated normally with white light?
- ◇ **D** ◇ *5points* ◇ Is any other color of visible light having a maximum on the surface of oil in part **C**?

PROBLEM 3 ◇ GALILEAN TELESCOPE ◇ *30points*

A Galilean telescope is a lens system made of a converging objective lens of focal length $f_o$ and diverging eyepiece of focal length $-f_e$, with $f_e > 0$, at distance $l < f_o$ from each other.

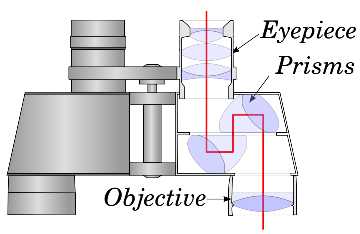
- ◇ **A** ◇ *5points* ◇ Carefully draw a diagram of rays of a distant star viewed through this telescope.
- ◇ **B** ◇ *10points* ◇ What is the distance of the image of distant stars from the eyepiece? Is this image real or virtual? Inverted or upright?
- ◇ **C** ◇ *5points* ◇ What should be the length of the telescope $l$ be in terms of $f_o$ and $f_e$ so that the image of distant stars is viewed with a relaxed eye.
- ◇ **D** ◇ *10points* ◇ What is the angular magnification of the case described in part **C**?

PROBLEM 4 ◇ OPTICS IN WATER ◇ *20points*

A lens made of flint glass of refractive index $n_{glass} = \frac{8}{5} = 1.6$ is flat on one side, and convex, with curvature 40 $cm$ on the other side.

- ◇ **A** ◇ *5points* ◇ What is the focal length of this lens in air ($n_{air} = 1$)? is the lens converging or diverging in air?
- ◇ **B** ◇ *5points* ◇ What is the focal length of this lens in water ($n_{water} = \frac{4}{3} \approx 1.33$)? Is the lens converging or diverging in water?
- ◇ **C** ◇ *5points* ◇ What is the focal length of a bubble of air of radius $R$ in water? Is it a converging or diverging lens?

Binoculars often use total internal reflection in $45° - 45° - 90°$ prisms made of glass like in this diagram.




- ◇ **D** ◇ *5points* ◇ Would binoculars work if their prisms are immersed in water?