Student ID Number: _____

PRELIMINARY EXAMINATION
DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part D, 8 January 2002, 14:00 - 17:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.

2. All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.

3. For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.

4. Your assigned student ID Number, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.

5. All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.

6. Each problem is worth 10 points.

7. Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

D1. The surface temperature of the Sun is $T_0 = 5500$ K and its radius is $R = 7 \times 10^5$ km. The mean distance between the Sun and Pluto is $L = 5.9 \times 10^9$ km and the radius of Pluto is $r = 1150$ km. Assume that the Sun and Pluto absorb all electromagnetic radiation incident upon them and that the planet has reached the steady-state.

(a) (5 points) Estimate the temperature on the Pluto's surface assuming that the heat conduction through Pluto is fast enough so that the temperature of the irradiated and dark parts of the surface is the same.

(b) (3 points) Estimate the mean temperature on the Pluto's surface assuming that the dark part of the surface is at $T_d = 0$ K.

(c) (2 points) Mercury is about hundred times closer to the Sun than Pluto. What are the temperatures on the Mercury's surface corresponding to assumptions in (a) and (b)?

D2. Two observers agree to discuss a number of physics problems in relation to four particular events: A, B, C, and D. One observer is stationary, and he labels the (x, ct) coordinates of these events as follows (in units of meters):

A(600,0), B(1000,0), C($1666\frac{2}{3}$,0), D($1666\frac{2}{3}$,$1333\frac{1}{3}$).

The other observer is moving with respect to the first with a velocity $v_x = 0.8c$ and she sets her clock to zero as she passes the first observer standing stationary at point O.

(a) (2 points) Draw a diagram, showing all these events, indicating the temporal and spatial relationship between them.

(b) (3 points) What are the coordinates of the event D in a system moving with the second observer?

(c) (3 points) What is the velocity, measured in the moving coordinates, for a particle with moves from A to D?

(d) (2 points) The line CD represents a particle not moving with respect to the x-axis. How far does the moving observer say the particle is away from O at the instant that the particle passes through D?

D3. The one dimensional equation of motion for an electron which is loosely bound to a positively charged ion, and subjected to an oscillatory driving electric field $E_o \exp(-i\omega t)$, is given by:

$$m\frac{d^2\tilde{x}}{dt^2} + m\gamma\frac{d\tilde{x}}{dt} + m\omega_o^2\tilde{x} = -eE_o\exp(-i\omega t),$$

where $\tilde{x}$ is the displacement of the electron from the stationary ion, $-e$ is the charge on the electron, m is its mass, ω_o is the resonance frequency of the bound electron, and γ is a damping constant.

(a) (3 points) From the above, derive an expression for the frequency dependent complex conductivity $\tilde{\sigma}(\omega)$ of a gas comprised of N identical singly ionized atoms per unit volume. Hint: ionized implies that the electrons are completely free.

(b) (2 points) For a dilute plasma (low density ionized gas), one may further approximate the conductivity derived in part A — what is this approximation? Show that this leads to a purely imaginary conductivity.

(c) (3 points) For the case of the dilute plasma, show that the refractive index is given by:

$$\bar{n} = (1 - \omega_p^2/\omega^2)^{1/2} \quad ,$$

where the plasma frequency $\omega_p = (Ne^2/m\epsilon_o)^{1/2}$; you may assume $\epsilon = \epsilon_o$ and $\mu = \mu_o$. Hint: you will need to solve Maxwell's equations.

(d) (2 points) Briefly comment on the implications of your result to (c) for wave propagation and dissipation in a dilute plasma, in the cases where (i) $\omega > \omega_p$ and (ii) $\omega < \omega_p$.