Physics 7C, Fall 2000, Section 1
Instructor: Adrian Lee

Second Midterm Examination, Monday November 6

Name:_____

Student ID:_____

Discussion Section Number/Time/TA:_____

Please write on the paper provided. You can write on both sides of the page. You may use one 8.5" x 11" sheet of double-sided notes.

Score

_____
Problem 1 (40 pts)

_____
Problem 2 (40 pts)

_____
Problem 3 (40 pts)

_____
Total

1) The Earth has radius R and is orbiting the Sun at radius r. Ignore the effect of the atmosphere (greenhouse effect) and assume that the Sun and earth have emissivity = 1.

a) Show that the surface temperature of the Earth is given by

$$T^4 = \frac{P_{Sun}}{16 \pi \sigma r^2}$$

where P_{Sun} is the radiant power output of the Sun. (25 pts)

b) Evaluate the temperature numerically. Use $T_{Sun} = 5500K$, $R_{Sun} = 7 \times 10^8$ m, $\sigma = 5.7 \times 10^{-8}$ W/(m^2 K^4), R = 6.4 x 10^6 m, r = 1.5 x 10^{11} m. Do you conclude that the atmosphere term is important? (15 pts)

2) Consider an electron with a kinetic energy of 1 keV. The rest mass of an electron is 511 keV/c^2.

a)   What is the momentum p of the electron? (15 pts)

b)   A stream of such electrons diffracts through an aperture. What size does the aperture have to be to have the first minimum of the diffraction pattern at 10 deg from the original stream?   What could be used to produce such apertures (a decent guess is enough)? (10 pts)

c)   Do the electrons have relativisitic velocities, i.e. is the γ (gamma) factor appreciably different from 1? (15 pts)

3)   The "Pole Vaulter" Paradox

A pole vaulter is running with a pole at $v = \sqrt{3}/2\ c$. Her pole has a proper length of L. She runs into a barn with proper length L/2 with doors on the front and back. When the pole vaulter runs into the barn, a farmer tries to close both front and back doors at the same time, but only for an instant, and then reopens them.

a)   What is the length of the pole from the farmer's perspective? What is the length of the Barn from the pole vaulter's perspective? From the farmer's perspective can he close the barn doors at the same time? (10 pts)

b)   Are the doors closed at the same time for the pole vaulter? What is the expression for the time interval of the door closings in the pole vaulter's frame? What is the interpretation of the sign of the expression? (15 pts)

c)   In the pole vaulter's frame give an expression for what the time interval would have to be to avoid an accident. Comparing the answers of (b) and (c), is there an accident? (15 pts)