Physics 212 FINAL EXAMINATION Jan. 2008

I. A laser beam is sent from earth at $t_1 = 2.00\,s$ and detected on the moon at $t_2 = 3.21\,s$. What is the travel time of the beam for an observer moving in a perpendicular direction at speed $.6c$?

II. 10^6 α-particles incident on a metal sheet are scattered between 45° and 90°.

a) How many will be scattered at angles > 45°?

b) How many will be scattered between 45° and 90° if their speed is doubled?

III. An electron of vanishing angular momentum ($\ell = 0$) is placed in the potential

$$U(r) = 0 \quad \text{for } r < a$$

$$U(r) = \infty \quad \text{for } r > a$$

The eigenvalues of energy are $E_n = n^2 E_1$, $E_1 = \pi^2\hbar^2/2ma^2$ and the corresponding eigenfunctions

$$\psi_{n1} = \frac{1}{\sqrt{2\pi a}}\,\frac{1}{r}\,\sin\left(\frac{n\pi r}{a}\right), \quad r < a$$

If the wave function of the electron is (at $t = 0$)

$$\psi = C \sin\left(\frac{\pi r}{a}\right)$$

P.T.O.

1 - Calculate c

2 - If the energy of the electron is measured, what values can be found and with what probabilities?

3 - What is the mean value $\overline{E}$ of the energy?

4 - Energy is measured and the value $E = E_2$ is found, calculate $P(r)$ where $P(r)\,dr$ is the probability to find the electron in the interval dr. Sketch $P(r)$.

TABLE of INTEGRALS

$$\int x \sin x \, dx = \sin x - x \cos x$$

$$\int x \cos x \, dx = \cos x + x \sin x$$

$$\int x^2 \sin x \, dx = -(x^2 - 2)\cos x + 2x \sin x$$

$$\int x^2 \cos x \, dx = (x^2 - 2)\sin x + 2x \cos x$$