Physics 237, Midterm Exam #1

Tuesday February 20, 2018
8.00 am – 9.30 am

Do not turn the pages of the exam until you are instructed to do so.

Exam rules: You may use *only* a writing instrument while taking this test. You may *not* consult any calculators, computers, books, nor each other.

Problems 1 and 2 must be answered in exam booklet 1. Problems 3 and 4 must be answered in exam booklet 2. The answers need to be well motivated and expressed in terms of the variables used in the problem. You will receive partial credit where appropriate, but only when we can read your solution. Answers that are not motivated will not receive any credit, even if correct.

At the end of the exam, you need to hand in your exam, the blue exam booklets, and the equation sheet. All items must be clearly labeled with your name, your student ID number, and the day/time of your recitation. **If any of these items are missing, we will not grade your exam, and you will receive a score of 0 points.**

You are required to complete the following *Honor Pledge for Exams*. Copy and sign the pledge before starting your exam.

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

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Name: _____

Signature: _____

Problem 1 (30 points) **ANSWER IN BOOKLET 1**

Consider a particle with charge e and rest mass m_0. The particle is accelerated to relativistic speeds by an accelerating potential V.

a) What is the de Broglie wavelength of this particle as function of V?

b) Show that the expression obtained in a) is consistent with assumption de Broglie made in the non-relativistic limit expressed in terms of the rest mass of the particle and its velocity.

Problem 2 (30 points) **ANSWER IN BOOKLET 1**

The Wilson-Sommerfeld quantization rule states that

> *For any physics system in which the coordinates are periodic functions of time, there exists a quantum condition for each coordinate. These quantum conditions are*
>
> $$\oint p_q \, dq = n_q h$$
>
> *where q is the one of the coordinates, p_q is the momentum associated with that coordinate, n_q is a quantum numbers which taken on integral values, and $\oint$ means that the integration is taken over one period of the coordinate q.*

a) Show how the Bohr quantization of angular momentum follows from the Wilson-Summerfeld rule.

b) Show how Planck's quantization law follows from the Wilson-Summerfeld rule.

Note: the area of the ellipse $x^2/a^2 + y^2/b^2 = 1$ is πab.

Problem 3 (35 points) **ANSWER IN BOOKLET 2**

The energy of a linear harmonic oscillator is equal to $E = p_x^2 / 2m + Cx^2 / 2$. The angular frequency of this oscillator is $\omega = \sqrt{C / m}$.

a) Show, using the uncertainty relations, that the energy of the linear harmonic oscillator can be written as

$$E = \frac{h^2}{32\pi^2 m x^2} + \frac{Cx^2}{2}$$

b) Show that the minimum energy of the oscillator is $hv/2$ where

$$v = \frac{1}{2\pi}\sqrt{\frac{C}{m}}$$

Problem 4 (5 points) **ANSWER IN BOOKLET 2**

Please include the proper answer for part a and b in your exam booklet.

a) (3 points) What is the best baseball team in the USA
   1. Yankees.
   2. Mets.
   3. Red Sox.
   4. Buffalo Bills
   5. AJAX

b) (2 points) In which country was the new 23-kg mass standard defined?

   1. The Netherlands.
   2. France.
   3. Germany.
   4. China.