Student ID Number: ________

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part C, 8 January 2002, 09:00 - 12:00

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

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C1. Consider the Yukawa potential energy (named for the person who introduced it in the theory of nuclear forces) for a point particle, mass m, at a distance r from the origin of an inertial frame:

$$V(r) = -\frac{ke^{-ar}}{r}$$

where k and a are positive constants.

(a) (2 points) Determine the force on the particle.

(b) (1 point) The force has a certain very important property. What is that property? What does that property imply about a conserved quantity?

(c) (1 point) Use that property to write down the radial equation of motion without any derivation.

(d) (3 points) Show by direct substitution that the radial equation of motion has a solution for uniform circular motion at radius r_0 (you need not try to solve that equation for the value of r_0). What is the angular velocity in terms of r_0?

(e) (3 points) Treat small deviations from r_0 and show that those deviations correspond to a simple harmonic oscillator motion. Determine the angular frequency of that SHO motion.

C2. An ideal gas for which $c_V = \frac{9}{2}R$ is taken from point a to point b in Figure 4-8. Let $P_2 = 2P_1$ and $v_2 = 2v_1$. For the following calculations, express the answer in terms of R and T_1.

(a) (2 points) Compute the heat supplied to the gas, per mole, along the path $a \to c \to b$.

(b) (4 points) Compute the heat supplied to the gas, per mole, along the path $a \to d \to b$.

(c) (4 points) Compute the heat supplied to the gas, per mole, along the path $a \to b$.

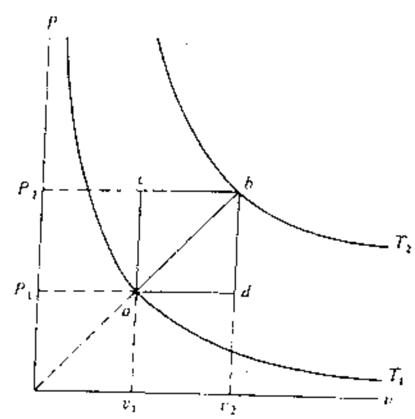

Figure 4-8

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

Part C, 20 August 2001, 09:00 - 12:00

C3. A two-level system has two states, $|0\rangle$ and $|1\rangle$, which are weakly coupled with a matrix element $V > 0$. Thus, the Hamiltonian is

$$\begin{aligned} H|1\rangle &= V|0\rangle \\ H|0\rangle &= V|1\rangle. \end{aligned}$$

(a) (3 points) At $t = 0$ a measurement is performed and the system is found to be in the state $|1\rangle$. What is the probability that a second measurement performed at $t > 0$ will find the system in state $|1\rangle$?

(b) (2 points) For which $t > 0$ will there be 100% probability that the system is in the state $|0\rangle$? Interpret your results in terms of what you know about a spin 1/2 particle in a magnetic field.

(c) (3 points) Suppose that a measurement is again performed at $t = 0$ yielding that the system is in state $|1\rangle$; however, this time immediately after the measurement, the energies of the two states are shifted. The energy of state $|1\rangle$ is shifted up by $+V$, and the energy of state $|0\rangle$ is shifted down by $-V$. Thus, the Hamiltonian is now

$$\begin{aligned} H|1\rangle &= V|0\rangle + V|1\rangle \\ H|0\rangle &= V|1\rangle - V|0\rangle. \end{aligned}$$

What is the probability at time $t > 0$ that a second measurement with find the system in state $|1\rangle$?

(d) (2 points) Now suppose that before the second measurement is performed, the energy shift described by the Hamiltonian in part (c) is turned off, and the system reverts to the Hamiltonian in part (a). If this occurs at time t_o, how can t_0 be chosen so that the probability of finding the system in the state $|1\rangle$ is independent of time for $t > t_o$? Interpret your results in terms of what you know about a spin 1/2 particle in a magnetic field.