

Student ID Number: _____

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

Part A, 17 August 2001, 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

PRELIMINARY EXAMINATION

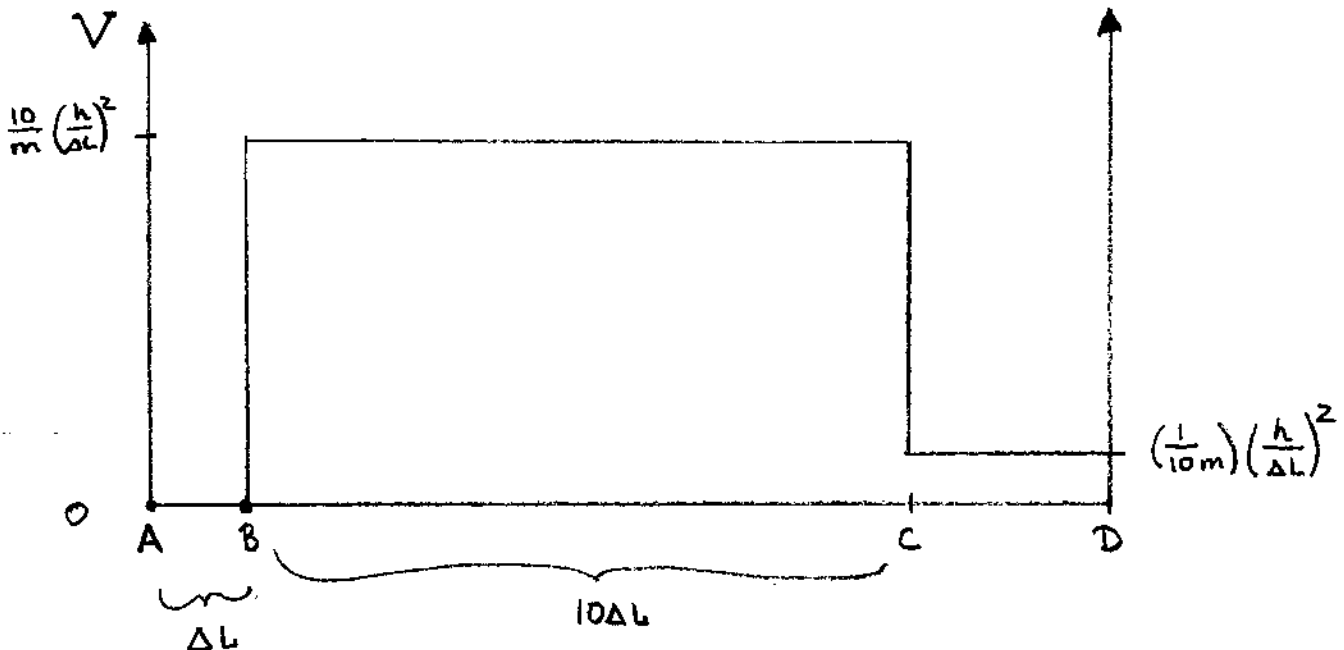
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A1. Consider a one-dimensional, nonrelativistic particle of mass m which can move in the three regions defined by points A, B, C, and D. The potential from A to B is zero; the potential from B to C is $\frac{10}{m}(\frac{h}{\Delta L})^2$; and the potential from C to D is $\frac{1}{10m}(\frac{h}{\Delta L})^2$. The distance from A to B is ΔL ; the distance from B to C is $10\Delta L$; and the distance from C to D is chosen such that the ground state has the same probability between A and B as between C and D.

- (2 points) For the ground state, the physics of this potential is very close to that of two independent infinite square wells. Why? Exploit this fact to estimate the distance from C to D.
- (2 points) Sketch the ground state wave function, indicating the relative signs in the three regions and the rough relative amplitudes (e.g., which is bigger).
- (6 points) Now consider how to obtain the exact solution. Express the ground state wave function in terms of four normalization constants, plus the energy and the distance from C to D. Write down equations which determine the six unknowns but do not attempt to solve them. However, you should explicitly compute all integrals and derivatives.



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A2. Two identical tanks of water are at absolute temperatures T_A and T_B respectively, where $T_A > T_B$. The tanks each have a heat capacity C , and they are thermally isolated from their environment. Suppose that a heat engine is installed in contact with the two tanks, in order to extract useful work from their temperature difference.

- (a) (4 points) Suppose that the engine is completely inefficient and generates no work. What will be the final temperature T_f of the tanks at equilibrium?
- (b) (4 points) Suppose instead that the engine is the most efficient engine possible. What will be the final temperature T_f of the tanks at equilibrium?
- (c) (4 points) How much work will have been generated by the efficient engine of part (b)?

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A3. A $12\mu F$ capacitor C_1 consists of plates A and B. An $18\mu F$ capacitor C_2 consists of plates C and D.

- (a) (3 points) Each are charged up by a 10 V battery such that plates A and C are positively charged. They are disconnected from the battery and connected into a series circuit with plate A connected to plate D and plate B connected to plate C, and the system allowed to come to equilibrium. What charge is now on plate D?
- (b) (4 points) Both capacitors C_1 and C_2 have square plates of side x_1 cm and plate separation d cm. The difference is that C_1 has only air between its plates, but C_2 also has a square plate of dielectric of side x_1 , relative permittivity ϵ_r and thickness t . In terms of ϵ_r , what fraction (t/d) of the gap is occupied by the dielectric?
- (c) (3 points) Capacitor C_2 is again charged up by a battery of voltage V , and remains connected to it. What force is required to extract the plate of dielectric from the gap? Give answer in terms of V and x_1 .