

PHY 2060 Fall 2005 — Final Exam

Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. To maximize your score, you should briefly explain your reasoning and show all working. Give all final answers in terms of variables defined in the problem, and/or any of the following quantities: G (the gravitational constant), g (the acceleration due to gravity near the Earth's surface), M_E , R_E , and T_E (the Earth's mass, radius, and rotational period, respectively), and c (the speed of light in a vacuum). Please try to write neatly!

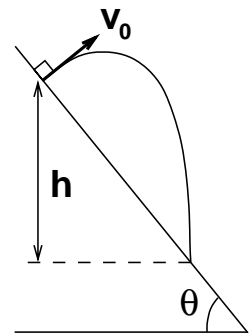
During this exam, you may use up to four formula sheets. You are not permitted to consult any other books, notes, or papers, to use calculators or any other electronic device, or to communicate with anyone other than the proctor. In accordance with the UF Honor Code, by turning in this exam to be graded, you affirm the following pledge: *On my honor, I have neither given nor received unauthorized aid in doing this assignment.*

1. A laboratory worker observes that an electron passes between two plates a distance d apart in a time interval t . How much time would have elapsed as measured by the electron's wristwatch?
2. A bullet of mass m is fired horizontally and embeds itself in a stationary target of mass M that is connected to an ideal, horizontal spring, the other end of which is attached to an immovable object. The spring, which has constant k and is initially relaxed, compresses a distance d before the bullet and target come to a halt.
 - (a) Find the work done by the spring in bringing the bullet and target to a halt.
 - (b) Find the speed of the bullet before it hits the target.
3. Two observers A and B are at rest with respect to one another and measure their separation to be d . A rocket of proper length L is fired at velocity v in a direction parallel to the line connecting A and B .
 - (a) How much time elapses (according to the observers) between the moment the tip of the rocket passes A and the moment the tail of the rocket passes A ?
 - (b) How much time elapses (according to the observers) between the moment the tip of the rocket passes A and the moment the tip of the rocket passes B ?
4. Four identical particles of mass m are located in deep space, one particle at each corner of a square of sides l . The particles are now released simultaneously from rest. The moment after the release, what is the magnitude of each particle's acceleration?

5. A block of mass m_1 , attached to an ideal spring having spring constant k , oscillates on a horizontal, frictionless surface between coordinates $x = x_0$ and $x = -x_0$. At a moment when the block is at $+x_0$, a second block of mass m_2 is dropped vertically on top of it.
- What is the *change* in the period of the oscillation?
 - What is the *change* in the total mechanical energy?
 - What is the *change* in the amplitude of the oscillation?

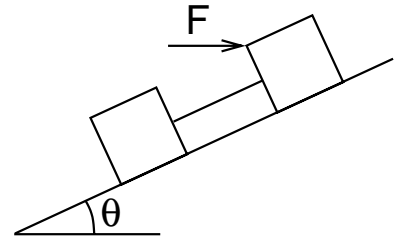
You may assume that the surfaces of the two blocks are so rough that the blocks move together at all times after they come in contact.

6. A ladder has length l , mass m , and uniform mass per unit length. The ladder leans against a vertical, frictionless wall. The coefficient of static friction between the ground and the ladder is μ_s . A person of mass M wishes to climb three-quarters of the way up the ladder. What is the minimum angle θ between the ladder and the ground that will ensure the system remains stable during the entire climb?
7. An irresponsible tourist is climbing high up the Great Pyramid of Cheops, which has sloping faces that make an angle θ with the ground. The tourist throws a pebble with an initial speed v_0 in a direction perpendicular to one of the faces. The pebble hits the face a vertical distance h below the tourist. Find h under the assumption that drag forces are negligible.



8. A plane of mass m is initially traveling at a steady speed v_0 and altitude h . The vertical lift force generated by the wings, $L = \beta v^2$, is proportional to the square of the plane's speed v . Suppose that the plane now moves to a slightly different altitude $h + y$.
- Assuming conservation of mechanical energy, calculate the plane's new speed v as a function of y .
 - By applying Newton's laws to the plane, find a differential equation for y and hence show that the plane undergoes simple harmonic oscillations about its original altitude h .
 - Find the frequency of the oscillations.

9. Two identical blocks, each of mass m , rest on a plane inclined at angle θ to the horizontal. The coefficient of kinetic friction between the blocks and the slope is μ_k . The blocks are connected by an ideal string that runs parallel to the plane, and the upper block is pushed by an constant external force of magnitude F acting horizontally, as shown in the figure. The external force is strong enough to cause the blocks to accelerate up the slope. Find the magnitude of this acceleration.



10. A thin, uniform stick of mass m and length l is pivoted at one end. A similar stick, half as long and of mass $m/2$, is rigidly attached to the first stick as shown in the figure. The combined object is held horizontally and then released from rest.
- Find the angular acceleration of the object immediately after it is released.
 - What is the magnitude of the force \mathbf{F}_0 exerted by the pivot on the object immediately after the latter is released?

