Exam 2—Phys171—Spring 2002   Prof. Ted Jacobson
Monday, April 22, 2002   Room 4117, (301)405-6020

Notes: *1) There are ten problems, worth a total of 100 points. 2) The first eight problems (and perhaps the last two as well) should require very little time to complete. If you are not getting the answer quickly you should move on and return to the problem later. 3) Make sure you indicate your reasoning and show your work if you want to obtain partial credit.*

1. A car starts from rest and accelerates on a level road so that the wheels do not slip. Consider the system consisting of the whole car, incuding engine, body, wheels, etc. Give the answer **and a one line explanation** for the following four questions: (a) What external force accelerates the system? (b) Does this force do work on the system? (c) Is mechanical energy of the system conserved? (d) Is the total energy of the system conserved? [10 *points*]

2. A car of mass m accelerates from rest with a constant acceleration a. What is the power delivered by the engine as a function of time t? [5 *points*]

3. Two pucks of mass m_1 and m_2 lying on a frictionless table are connected by a straight massless spring of force constant k. A horizontal external force F_1 is exerted only on m_1, with direction along the spring away from m_2. What is the magnitude of the acceleration of the center of mass of the pucks? [10 *points*]

4. A ball of mass m moves with speed v to the right toward a much heavier bat that is moving to the left with speed v. What is the speed of the ball after it makes an elastic collision with the bat. [10 *points*]

5. The figure shows the behavior of a projectile just after it has broken up into three pieces. What was the speed of the projectile just before it broke up? [10 *points*]

6. A block of mass m, starting from rest, is pulled by a string up a rough inclined plane that makes an angle θ with the horizontal. The tension in the string is T and the string is parallel to the inclined plane. After traveling a distance L the speed of the block is v. Find an expression for the work done by the frictional force in terms of these quantities. [10 *points*]

7. At what speed is the relativistic kinetic energy of an electron equal to its rest energy? (Give your answer as a multiple of the speed of light c.) [5 *points*]

8. A 15 g ball is shot from a spring gun whose spring has a force constant of 600 N/m. The spring is initially compressed 5 cm. How high will the ball go if the gun is aimed vertically? [10 *points*]

9. A force $\mathbf{F} = \left(2\,\text{N/m}^2\right) x^2\,\mathbf{i}$ is applied to a particle. (a) Find the work done on the particle as is moves a total distance of 5 m parallel to the y axis from the point (2 m, 2 m) to the point (2 m, 7 m). (b) Find the work if the particle instead moves a distance of 5 m in a straight line from (2 m, 2 m) to (5 m, 6 m). (c) Is this a conservative force? Explain why or why not. [15 *points*]

10. An alpha particle (a helium-4 nucleus) moving at speed v_0 in the "lab frame" collides head-on elastically with a carbon-12 nucleus at rest. What is the velocity (magnitude and direction) of the alpha particle in the center of mass frame (a) before the collision? (b) after the collision? (c) What is the final velocity of the alpha particle in the lab frame? (A carbon-12 nucleus is three times as massive as an alpha particle.) [15 *points*]