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

pages, problems, points

1. 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?

2. 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 force F_1 is exerted only on m_1 along the spring away from m_2. What is the magnitude of the acceleration of the center of mass of the pucks?

3. The figure shows the behavior of a projectile just after it has broken up into three pieces. What was the speed of the projectile the instant before it broke up?

4. A 300 g handball moving with a speed of 5.0 m/s strikes the wall at an angle of $40°$ and then bounces off with the same speed at the same angle. It is in contact with the wall for 2 ms. What is the average force exerted by the ball on the wall?

5. The uniform sheet of plywood in the figure has a mass of 20 kg. What are the (x, y) coordinates of its center of mass if the origin lies at the lower left corner and the sides run along the coordinate axes?

6. 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.

7. 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.)

8. 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.

9. A car starts from rest and accelerates on a level road so that the wheels do not slip. Give the answer and a one line explanation for the following four questions: (a) What force accelerates the car? (b) Does this force do work? (c) Is mechanical energy conserved? (d) Is total energy conserved?

10. 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.)

11. 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?

12. A force $\mathbf{F} = (2\,\text{N/m}^2)\,x^2\,\mathbf{i}$ 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.

13. The potential energy of a 4 kg object is given by $U = 3x^2 - x^3$ for $x \leq 3$ m, and $U = 0$ for $x \geq 3$ m, where U is in joules and x is in meters. (a) At what positions is this object in equilibrium? (b) Sketch a decent plot of U versus x. (Do not use your calculator to do this. It may well give you a misleading result.) Show clearly the location of the zeros an stationary points. (c) For each equilibrium point state whether it is stable, unstable, or neutral. (d) If the total energy of the particle is 12 J, what is its speed at $x = 2$ m?