FINAL EXAM

Physics 9A Sections A and C **NAME:**

May 16, 2007 **ID #:**

General Instructions: This examination is closed book. Only a calculator is allowed. Please show all your work and box your answers. Credit will only be given for *complete* solutions. Answers must have correct units. There are nine problems on nine pages. Note that not all the problems are worth the same number of points.

[20 points] 1. The catapult of the aircraft carrier *USS Abraham Lincoln* accelerates an F/A-18 Hornet jet fighter from rest to a takeoff speed of 75 m/s in a distance of 90 m. Assume constant acceleration.

(a) Calculate the acceleration of the fighter.

(b) Calculate the time required to accelerate the fighter to takeoff speed.

[25 points] 2. Two ice skaters, Daniel (mass 60.0 kg) and Rebecca (mass 45.0 kg) are practicing. Daniel stops to tie his shoelace and, while at rest, is struck by Rebecca, who is moving at 13 m/s before she collides with him. After the collision, Rebecca has a velocity of magnitude 8 m/s at an angle of 35° from her initial direction. Both skaters move on a frictionless, horizontal surface of the rink. (a) What are the magnitude and direction of Daniel's velocity after the collision? (b) What is the change in total kinetic energy of the two skaters as a result of the collision?

[25 points] 3. A pickup truck has a wheelbase of 3.4 m. Ordinarily, 11,000 N rests on the front wheels, and 9,000 N on the rear wheels. A box weighing 4000 N is placed on the tailgate, 0.8 m behind the rear axle. How much total weight now rests on the rear wheels? On the front wheels?

(b) How much weight would need to be placed on the tailgate to make the front wheels come off the ground?

[25 points] 4. A asteroid of mass $m = 1000$ kg moves in a circular orbit around the sun, which has mass $M_{\text{sun}} = 2 \cdot 10^{30}$ kg. The radius of the orbit is $r = 4 \cdot 10^{11}$ m.

(a) What is the speed of the asteroid in its orbit?

(b) What is the period T?

(c) What is the kinetic energy?

(d) What is the gravitational potential energy?

(e) If the speed is doubled, will the asteroid escape? Explain your answer.

Newton's constant of gravitation is $G = 6.67 \cdot 10^{-11}$ N m^2/kg^2.

[25 points] 5. A hopper car of mass $M = 40000$ kg is rolling with velocity $v = 10$ m/s on a level track. The bearings and aerodynamics of the car are so well engineered that it can roll forever with constant velocity, unless something happens to it. Something happens: It begins to rain.

(a) What is the velocity of the hopper car after it has filled with 5000 kg of rain water?

(b) The rain stops and the hopper car springs a leak. What is the velocity of the car after all the water has leaked out? Explain your answer clearly.

(c) It starts raining again and the mass of the car increases at a rate of 30 kg every second. What force would you need to apply to keep the train moving at constant velocity?

[20 points] 6. A mass of 5 kg is attached to a spring of force constant $k = 2000$ N/m, and slides on a frictionless, horizontal surface. At $t = 0$ it has a position $x_0 = 0.08$ m and velocity $v = 1.5$ m/s.

(a) What is the total energy (kinetic plus potential)?

(b) What is the amplitude (maximum displacement from equilibrium) of the motion?

(c) What is the maximum velocity?

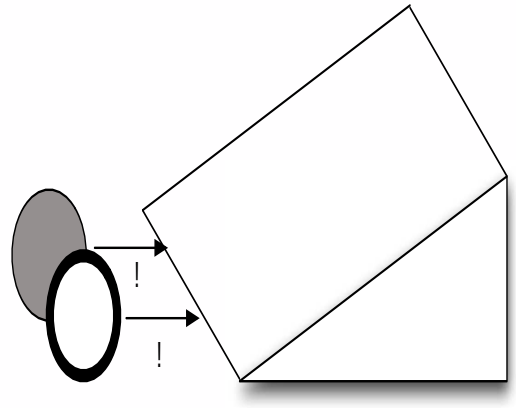
(d) What is the period?

(e) Sketch plots of $x(t)$ and $v(t)$ which contain at least one full period. Label all your axes with relevant numbers. Note: You should be able to make quite good sketches from your answers to parts (b-c) and the relation between x and v. That is, you do not necessarily have to compute functional forms for $x(t)$ and $v(t)$ for full credit.

[20 points] 7. The moment of inertia of a disk is $\frac{1}{2}mR^2$. The moment of inertia of a ring is mR^2. A disk and a ring with equal mass m and equal radii R both roll up a hill. They start with the same linear velocity v.

a) Clearly explain which will go higher.

b) Determine the height the ring will reach.

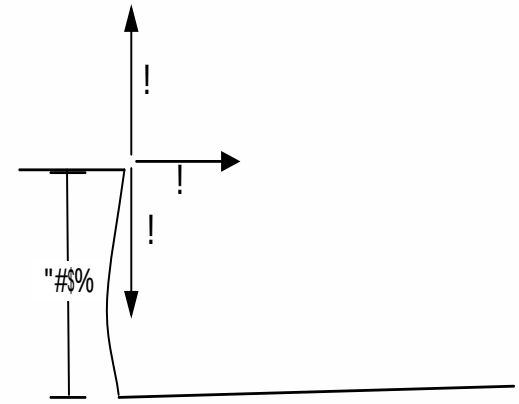


[20 points] 8. Three rocks, each of mass 12 kg, are thrown off a cliff with the same speed, 5 m/s. One is thrown straight up. One is thrown straight down. One is thrown directly horizontally. You are interested in their speeds just before they strike the ground, 18 meters below.

a) A physics 9 student claims that the one thrown down will have the greatest speed, followed by the one thrown horizontally, with the one thrown up hitting the ground moving slowest. Argue for or against her claim.

b) Calculate the range of the ball thrown horizontally.

c) Draw a force diagram for the horizontally-thrown ball just *after* it leaves the student's hand.



[20 points] 9. A girl is standing on a smooth surface and kicks a tall skinny box (1 m x 20 cm) very hard 25 cm above the bottom left corner as shown and in a horizontal direction. The distribution of mass in the box is uniform, and in the middle of the box is an X. The kick is hard enough to cause the box to slide along the ground while rotating. Describe whether the X initially moves to the right or the left and explain why, citing basic principles such and Newton's laws, and conservation of energy.