Physics 9A-B **Final Exam** **Name:**
June 12, 2007

Put your name on your exam. There are nine problems on five pages. Except for problem #1, no credit will be given for answers without work. Answers must have correct units. Good Luck!

[1] Circle the answer that correctly completes the sentence.
a) A track star is accelerating at the beginning of a race. The frictional force of the ground on his feet is (forward in the direction of motion | backward opposite to the motions | none of the above)

b) Many of the great rivers in the world have a tendency to flow from the pole towards the equator. Over time as they carry sediment toward the equator, the angular speed of the earth will (increase | decrease | not change) .

d) For an object given a sudden impulse, the impulse is in the same direction as the (momentum change | force | both of the above | none of the above).

e) A nano meter (nm) is (10^9 | 10^6 | 10^3 | 10^{-3} | 10^{-6} | 10^{-9} | none of the above) meters

f) The energy of a system is $E = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} m \dot{y}^2 - kx$. (p_x | p_y | both of the above | none of the above) is/are conserved.

g) If an unbalanced force acts on an object, then that object's momentum must always change (always | sometimes | never).

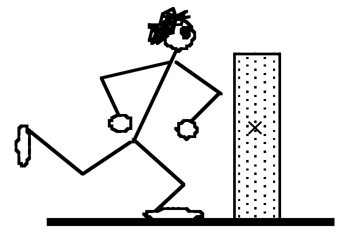
h) A net frictional force will break (time reversal | translational | rotational) invariance.

i) By making the radius of a hollow cylinder (large | small | none of the above), it can be made to roll as quickly down an inclined plane as a solid sphere.

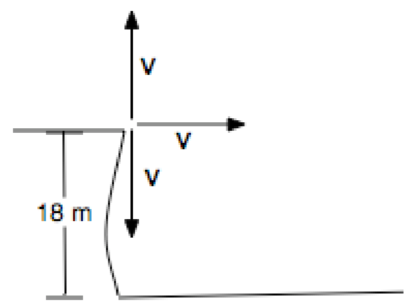
j) For circular motion, the tangential acceleration changes the (direction | magnitude | both of the above | none of the above) of the velocity.

Integrals & Constants:
$g = 9.8$ m/s^2 = 32 ft/s^2 $\quad$ $G = 6.67 \times 10^{-11}$ Nm^2/kg^2
water is 18 g/mole $\quad$ Avagadro's Number: 6×10^{23} particles/mole

[[2] A girl is standing on a smooth surface and kicks a tall skinny box (1 m × 20 cm) very hard 25 cm above the bottom left corner as shown. The distribution of mass in the box is uniform, and in the middle of the box is an ×. The kick is hard enough to cause the box to leave the ground. Describe whether the × moves to the right or the left and explain why.



[3] Three rocks, each of mass 12.0 kg, are thrown off a cliff with the same speed, 5 .00 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, 18.0 meters below.



a) (8 pts) 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) (8 pts) Calculate the range of the ball thrown horizontally.

c) (4 pts) Draw a free body diagram for the horizontally–thrown ball just after the ball leaves the student's hand.

4] A mass of 5.00 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 $x_o = 0.080$ m and velocity $v_o = 1.50$ m/s. a) (4 pts) What is the total energy (kinetic plus potential)?

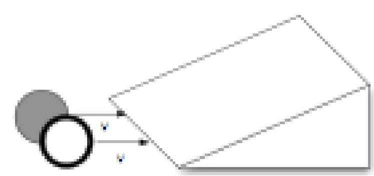
b) (4 pts) What is the amplitude (maximum displacement from equilibrium) of the motion?

c) (4 pts) What is the maximum velocity?

d) (4 pts) What is the period?

e) (4 pts) 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.

[5] The moment of inertia of a solid disk is $\mathcal{I} = \frac{1}{2}mr^2$. The moment of inertia of a ring is $\mathcal{I} = mr^2$. 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) (10 pts) Clearly explain which will go higher.



b) (10 pts) Determine the height the ring will reach.

[6] A hopper car of mass M=40,000 kg is rolling with velocity v = 10.0 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) (8 pts) What is the velocity of the hopper car after it has filled with 5000 kg of rain water?

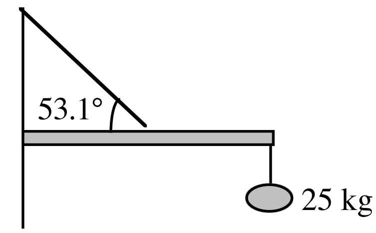
b) (4 pts) The rain stops and the hopper car springs a leak. What is the velocity of the car after all the water has leaked out? Explain your answer clearly.

c) (8 pts) It starts raining again and the mass of the car increases at a rate of 30.0 kg every second. What force would you need to apply to keep the train moving at constant velocity?

[7] A person on the rim of a Ferris wheel with radius 14.0 m is turning counter–clockwise. At the moment the person is at the top, their angular speed is 0.50 rad/s and is increasing at a rate of 0.40 rad/s^2. a) (10 pts) Find the magnitude and direction of the linear acceleration of the person at this instant.

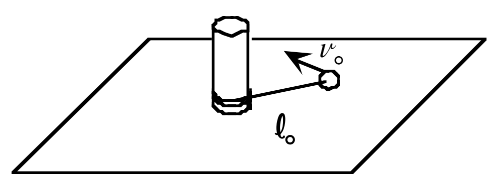
b) (10 pts) The person has a mass of 60.0 kg. Find the vertical component of the normal force of the seat on the person at the top.

[8] The uniform strut shown below has a mass of 10.0 kg, length of 5.0 m, and pivots freely about its left end. Find the tension in the cable that attaches at the mid–point of the strut. A mass of 25.0 kg hangs from right end of the strut.

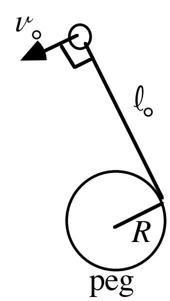


[9] A mass m moving with speed $v_\circ$ on a horizontal frictionless surface is fastened by a string to a peg as shown above. As the mass moves, it winds up on the fixed peg causing the mass to follow a spiral path inward. $v_\circ$ always remains perpendicular to the string.

a) (5 pts) What is the initial angular momentum and final angular momentum?



b) (5 pts) Is angular momentum about the center of the peg conserved? Explain.



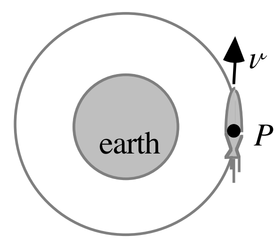
c) (5 pts) is energy conserved? Explain.

d) (5 pts) If the speed is $v_\circ$ when the string length is $\ell_\circ$, what is the speed when the string length has been reduced to $\ell_\circ/3$?

[10] Wile E. Coyote is in a circular orbit of radius $r_\circ$ and angular momentum $L_\circ$ around the earth as shown below. a) (5 pts) Write a formula for his initial energy total energy in terms of $L_\circ$, m, and $r_\circ$.

b) (5 pts) Make a graph of his effective potential energy $U_\circ$ and his initial energy $E_\circ$ on the graph.

c) (5 pts) At point P, he now fires his rocket engines tangent to his path so that his angular momentum increases to L where his speed is less than escape speed. Sketch his new orbit on the picture.



d) (5 pts) Write a new formula for his total energy E in terms of L, m, his new variable radius r, and radial speed $\dot{r}$ (the dot above r means time derivative).