Physics 1114 - General Physics I

Final Exam - 2013.12.13

Name: _____

Instructions: Please show all work on each problem, and give full explanations where needed. No points will be awarded for a correct answer, points are awarded on the work shown for each problem. When you are finished, please attach your cheat sheet to this final exam.

problem	points	score
1 (a)	5	
1 (b)	5	
2	6	
3	6	
4 (a)	6	
4 (b)	5	
4 (c)	5	
4 (d)	8	
5	5	
6 (a)	6	
6 (b)	5	
7	8	
8 (a)	3	
8 (b)	4	
8 (c)	4	
8 (d)	3	
9 (a)	5	
9 (b)	4	
9 (c)	4	
9 (d)	4	
9 (e)	3	
10	12	
Total	116	

1. You are sitting at a table in your fifth floor apartment when you see a strange object moving straight upward past your window. You window is 1.75 meters tall and it takes approximately 0.2 seconds for the object to go from the bottom ledge of the window to the upper ledge of the window. You assume the object has no internal propulsion, and is thus experiencing linear motion with constant acceleration.

(a) How far above the upper ledge of your window did the object go?

(b) How much time will elapse between the object passing the upper ledge of the window heading up and the object passing the upper ledge of the window heading down?

2. You are designing a cylindrical space station which will rotate about its central axis. The inhabitants of the space station will live next to the outer hull of the cylinder. The distance from the axis of rotation to the shell of the cylindrical hull will be 350 meters. How quickly will you have to rotate the station about the central axis so that the inhabitants experience at least $0.9g$? Express your answer both in meters per second and revolutions per minute.

3. A mass is oscillating with amplitude A at the end of a spring. How far (in terms of A) is the mass from the equilibrium position of the spring when the elastic potential energy equals the kinetic energy?

4. A block of mass M at rest on a table is attached to a bucket of mass m through a pulley of radius r and mass m_w as seen in the figure below.

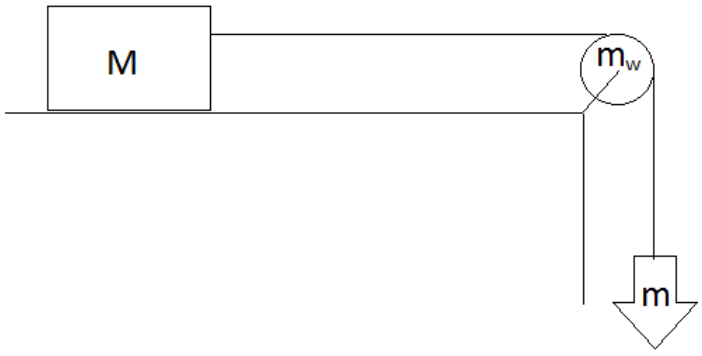

Figure to go along with problem 4.

(a) Draw a free body diagram for each of: the block of mass M, the bucket of mass m, and the pulley of radius r and mass m_w.

(b) Assuming that the table is frictionless and that the pulley does not rotate but allows the rope to slide effortlessly across it, what is the acceleration of the bucket once the system is set in motion?

(c) This time, assume that the table has a coefficient of kinetic friction μ_k once the system is in motion and that the pulley does not rotate but allows the rope to slide effortlessly across it. What is the requirement for the bucket to be accelerating downward?

(d) Finally, assume that the table has a coefficient of static friction μ_k once the system is in motion. The pulley rotates (hence the line does not slip along the pulley), and the moment of inertia for the wheel is $\frac{1}{2}m_w r^2$. Solve for the acceleration of the bucket.

5. A block is launched up a frictionless 40° slope with an initial speed v and reaches a maximum vertical height h. The same block is launched up a frictionless 20° slope with the same initial speed v. On this slope, what is the maximum vertical height that the block will reach?

6. A thin rod of mass M and length L is at rest on a frictionless table. A small circular block of mass M traveling with a speed v hits one of the ends of the rod. After the collision, the small block's final speed is $v/2$ in the same direction as before the collision. See the figure below. The moment of inertia for a thin rod rotated about an end is $ML^2/3$, while about the center of the rod is $ML^2/12$.

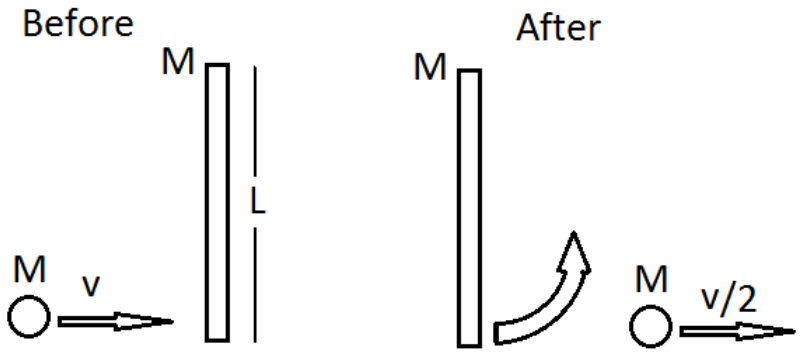

Figure to go along with problem 6.

(a) What is the rod's angular velocity after the collision?

(b) If the rod is fixed and free to rotate about the end which does not collide with the block, what is the rod's angular velocity after the collision?

7. You run from the Russell Building to the Science building at a constant speed v because you forgot your backpack. You then turn around and run back to the Russell Building at an unknown constant speed s. Your average speed for the entire trip is $0.8v$. Find s.

8. The acceleration due to gravity on the surface of a planet of radius r is g.

(a) A satellite is resting on the surface of the planet. Compute the gravitational force between the planet and the satellite using Newton's Law of Gravitation.

(b) If we use Newton's Second law, the force exerted on the satellite due to gravity is $F = m_{\text{sat}}g$. Set this equal to your answer from part (a) and solve for the the mass of the planet.

(c) The satellite is shot into a circular orbit around the planet at a distance of $2r$ above the surface. Compute the speed of the satellite.

(d) Compute the orbital period of the satellite.

9. A car of mass M starts from rest and travels around a circular track of radius r whilst speeding up at a constant rate. The car takes T seconds to go around the track once.

(a) What is the angular acceleration of the car?

(b) What is the tangential acceleration of the car at the instant when it completes one revolution?

(c) What is the radial acceleration of the car at the instant when it completes one revolution?

(d) What is the net acceleration of the car at the instant when it completes one revolution?

(e) What is the net force acting on the car at the instant when it completes on revolution?

10. An open cylindrical tank of wine sits at the edge of a table 1.5 meters above the ground. Initially, the depth of the wine in the tank is 1.2 meters. If the tank springs a hole in the side at its base, how far from the foot of the table should you be laying so that so that you catch the wine with your mouth?