MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Experimental Study Group

Physics 8.012 **Fall Term 2009**

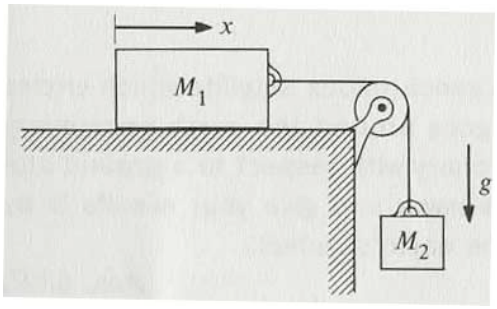
Problem Set 2

Due: September 25

Readings: (KK) Kleppner, Daniel and Kolenkow, Robert, An Introduction to Mechanics, McGraw Hill, Inc., New York, 1973, Chapter 2.

Problems: Chapter 2: 2, 4, 7, 9, 10, 16, 22

Problem 2: The two blocks shown in the figure are connected by a string of negligible mass. If the system is released from rest, find how far the block of mass m_1 slides in time t. Neglect friction.

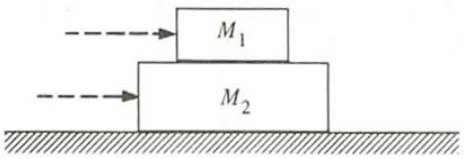


Problem 4: Two particles of mass m_1 and m_2 undergo uniform circular motion about each other at a separation R under the influence of an attractive force of magnitude F. The angular velocity is ω radians per second.

a) Show that $R = (F/\omega^2)(1/m_1 + 1/m_2)$.

b) Explain why you can think of this problem is equivalent to a single body of mass μ where $1/\mu = (1/m_1 + 1/m_2)$ undergoing circular motion of radius R due to the influence of a central attractive force of magnitude F.

Problem 7: Consider two textbooks that are resting one on top of the other. The lower book has $m_2 = 0.8$ kg m and is resting on a nearly frictionless surface. The upper book has mass $m_2 = 2.0$ kg . Suppose the coefficient of static friction is given by $\mu_s = 0.1$.

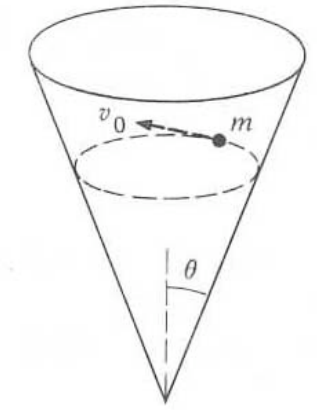


a) What is the maximum force which the upper book can be pushed horizontally so that the two books move together without slipping? Identify all action-reaction pairs of forces in this problem.

b) What is the maximum force which the lower book can be pushed horizontally so that the two books move together without slipping? Identify all action-reaction pairs of forces in this problem.

c) Explain why one of your forces in parts a) and b) is larger than the other.

Problem KK 2.9: A body of mass m is moving in a horizontal circle of radius r with a constant speed v_0 on the inside wall of a cone. Assume the wall of the cone is frictionless. The wall of the cone makes an angle θ with the vertical.



a) Draw a free body force diagram showing all the forces acting on the mass.

b) What is the speed of the mass?

c) How long will the mass take to go around the circle?

d) Now assume there is a coefficient of static friction μ_s. Find the maximum speed the mass can move on the inside of a cone and still move in a circular orbit of radius r.

Problem 2.10

The earth is spinning about its axis with a period of 23 hours 56 min and 4 sec. The equatorial radius of the earth is 6.38×10^{6} m. The latitude of Cambridge, Mass is $42^{o}\ 22'$.

a) Find the velocity of a person at MIT as they undergo circular motion about the earth's axis of rotation.

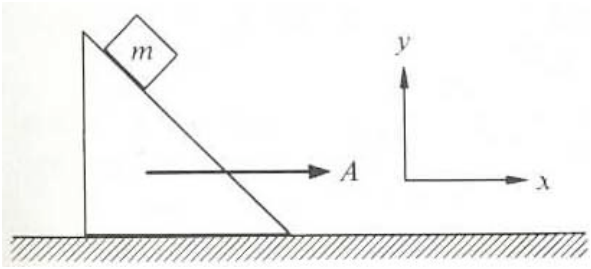
b) Find the person's centripetal acceleration.

c) The rotation of the Earth is slowing down. In 1977, the Earth took 1.01 s longer to complete 365 rotations than in 1990. What was the average angular deceleration of the Earth in the time interval from 1900 to 1977?

d) Find the radius of the orbit of a synchronous satellite which circles the earth. (A synchronous satellite goes around the earth once every rotation of the earth, so that its position appears stationary with respect to a ground station).

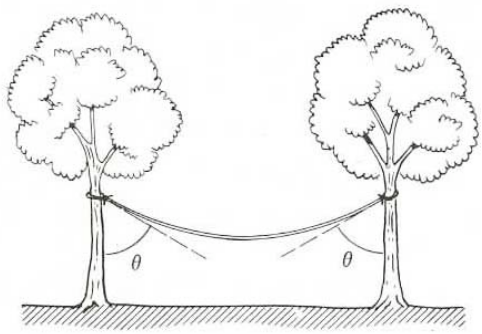
Problem 2.16

A 45^{o} wedge is pushed along a table with constant acceleration A. A block of mass m slides without friction down the wedge. Find its acceleration. (Gravity is directed down.)



Problem 2.22

Suppose a rope of mass m hangs between two trees. The ends of the rope are at the same height and they make an angle θ with the trees.



a) What is the tension at the ends of the rope where it is connected to the trees?

b) What is the tension in the rope at a point midway between the trees?