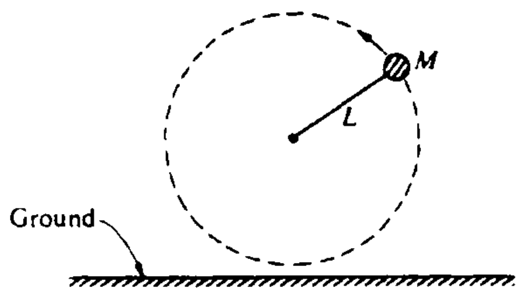
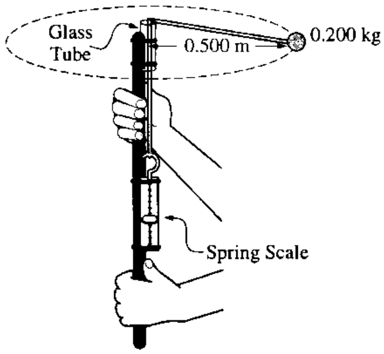


1. A ball of mass M attached to a string of length L moves in a circle in a vertical plane as shown above. At the top of the circular path, the tension in the string is twice the weight of the ball. At the bottom, the ball just clears the ground. Air resistance is negligible. Express all answers in terms of M, L, and g

a. Determine the magnitude and direction of the net force on the ball when it is at the top.
b. Determine the speed v_o of the ball at the top.
c. Draw a free body diagram for the ball when it is at the top of the circle and when at the bottom of the circle.
d. Is the tension in the cord greater when the ball is at the top of the circle or when at the bottom of the circle? Explain conceptually.

The string is then cut when the ball is at the top.

e. Determine the time it takes the ball to reach the ground.
f. Determine the horizontal distance the ball travels before hitting the ground.
g. If the ball was released at the point shown in the diagram rather than at the top of the circle, would it travel farther horizontally or less far? Explain.



2. To study circular motion, two students use the hand-held device shown above, which consists of a rod on which a spring scale is attached. A polished glass tube attached at the top serves as a guide for a light cord attached the spring scale. A ball of mass 0.200 kg is attached to the other end of the cord. One student swings the ball around at constant speed in a horizontal circle with a radius of 0.500 m. Assume friction and air resistance are negligible.

a. Explain how the students, by using a timer and the information given above, can determine the speed of the ball as it is revolving.

b. The speed of the ball is determined to be 3.7 m/s. Assuming that the cord is horizontal as it swings, calculate the expected tension in the cord.

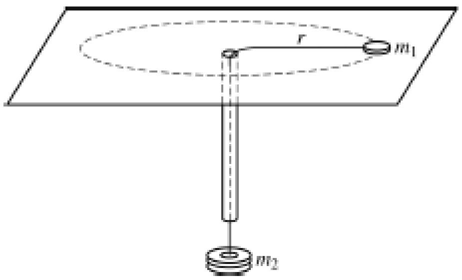
c. The actual tension in the cord as measured by the spring scale is 5.8 N. What is the percent difference between this measured value of the tension and the value calculated in part c?

d. The students find that, despite their best efforts, they cannot swing the ball so that the cord remains exactly horizontal.

   i. Draw vectors to represent the forces acting on the ball and identify the force that each vector represents.

   ii. Explain why it is not possible for the ball to swing so that the cord remains exactly horizontal.

   iii. Calculate the angle that the cord makes with the horizontal.



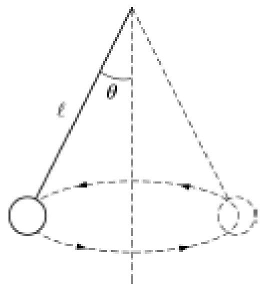
3. An experiment is performed using the apparatus above. A small disk of mass m_1 on a frictionless table is attached to one end of a string. The string passes through a hole in the table and an attached narrow, vertical plastic tube. An object of mass m_2 is hung at the other end of the string. A student holding the tube makes the disk rotate in a circle of constant radius r, while another student measures the period T.

   a. Derive the equation $T = 2\pi\sqrt{\frac{m_1 r}{m_2 g}}$ that relates T and m_2.

   The procedure is repeated, and the period T is determined for four values of m_2, where m_1 = 0.012 kg and r = 0.80 m. The data, which are presented below, can be used to compute an experimental value for g.

m_2 (kg)	0.020	0.040	0.060	0.080
T (s)	1.40	1.05	0.80	0.75

   b. What quantities should be graphed to yield a straight line with a slope that can be used to determine g?
   c. Plot the quantities determined in part (b), label the axes, and draw the best-fit line to the data. You may use the blank rows above to record any values you may need to calculate.
   d. Use your graph to calculate the experimental value of g.



4. A ball is attached to a string of length *l* swings in a horizontal circle, as shown above, with a constant speed. The string makes an angle θ with the vertical, and T is the magnitude of the tension in the string. Express your answers to the following in terms of the given quantities and fundamental constants.

a) On the figure below, draw and label vectors to represent all the forces acting on the ball when it is at the position shown in the diagram. The lengths of the vectors should be consistent with the relative magnitudes of the forces.

b) Determine the mass of the ball.

c) Determine the speed of the ball.

d) Determine the frequency of revolution of the ball.

e) Suppose the string breaks as the ball swings in its circular path. Qualitatively describe the trajectory of the ball after the string breaks but before it hits the ground.

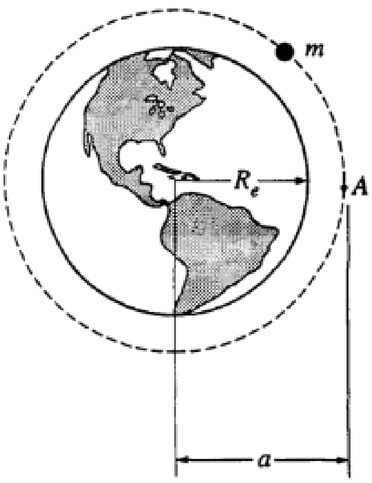
5. During a lunar eclipse, the Moon, Earth, and Sun all lie on the same line, with the Earth between the Moon and the Sun. The Moon has a mass of 7.4×10^{22} kg; Earth has a mass of 6.0×10^{24} kg; and the Sun has a mass of 2.0×10^{30} kg. The separation between the Moon and the Earth is given by 3.8×10^{8} m; the separation between the Earth and the Sun is given by 1.5×10^{11} m.

(a) Calculate the force exerted on Earth by the Moon.

(b) Calculate the force exerted on Earth by the Sun.

(c) Calculate the net force exerted on Earth by the Moon and the Sun.

6. A satellite of mass m is in a circular orbit around the Earth, which has mass M_e and radius R_e. Express your answers in terms of a, m, M_e, R_e, and G.



(a) Write the equation that can describe the gravitational force on the satellite.

(b) Write an equation that can be used to find the acceleration of the satellite.

(c) Is this acceleration greater, less than the acceleration g on the surface of Earth?

(d) Determine the velocity of the satellite as it stays on the same orbit.

(e) What is the orbital period of the satellite?