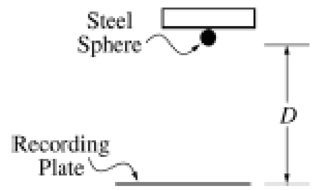
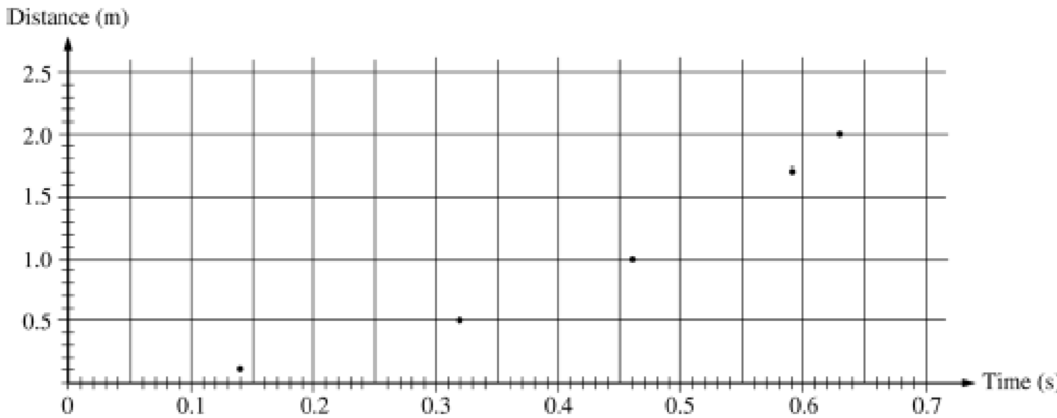
Broward County Schools
AP Physics 1
Review Questions



1. (15 points)

A student wishing to determine experimentally the acceleration g due to gravity has an apparatus that holds a small steel sphere above a recording plate, as shown above. When the sphere is released, a timer automatically begins recording the time of fall. The timer automatically stops when the sphere strikes the recording plate. The student measures the time of fall for different values of the distance D shown above and records the data in the table below. These data points are also plotted on the graph.

Distance of Fall (m)	0.10	0.50	1.00	1.70	2.00
Time of Fall (s)	0.14	0.32	0.46	0.59	0.63

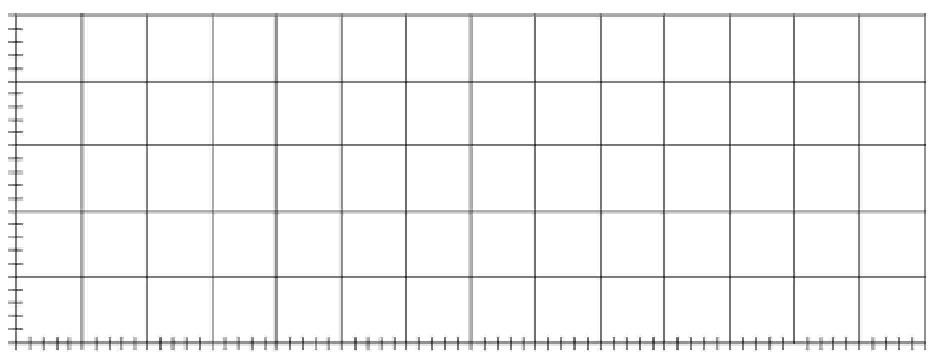


(a) On the grid above, sketch the smooth curve that best represents the student's data.

The student can use these data for distance D and time t to produce a second graph from which the acceleration g due to gravity can be determined.

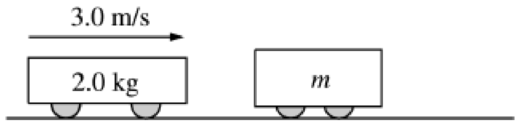
(b) If only the variables D and t are used, what quantities should the student graph in order to produce a linear relationship between the two quantities?

(c) On the grid below, plot the data points for the quantities you have identified in part (b), and sketch the best straight-line fit to the points. Label your axes and show the scale that you have chosen for the graph.



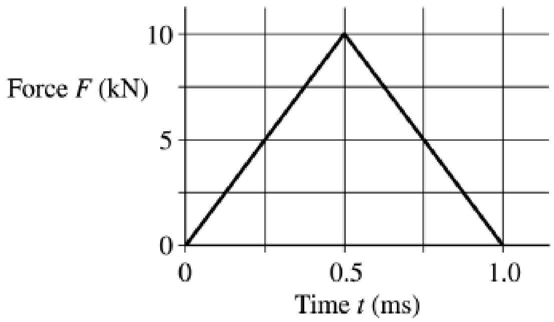
(d) Using the slope of your graph in part (c), calculate the acceleration g due to gravity in this experiment.

(e) State one way in which the student could improve the accuracy of the results if the experiment were to be performed again. Explain why this would improve the accuracy.



1. (15 points)

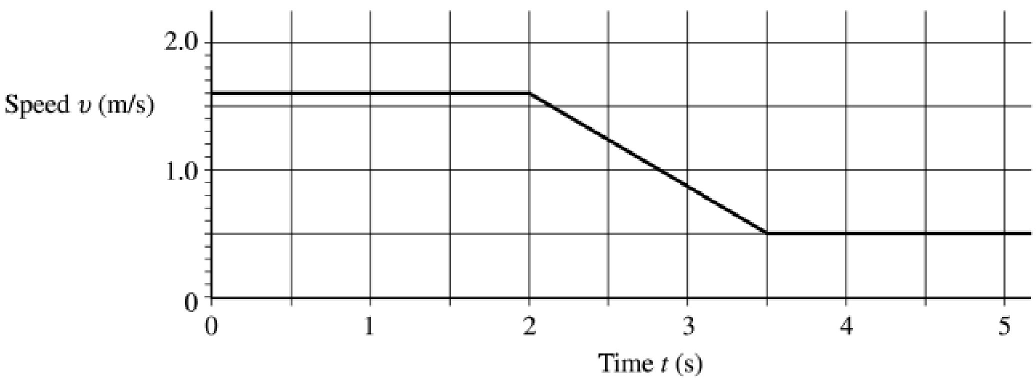
A 2.0 kg frictionless cart is moving at a constant speed of 3.0 m/s to the right on a horizontal surface, as shown above, when it collides with a second cart of undetermined mass m that is initially at rest. The force F of the collision as a function of time t is shown in the graph below, where $t = 0$ is the instant of initial contact. As a result of the collision, the second cart acquires a speed of 1.6 m/s to the right. Assume that friction is negligible before, during, and after the collision.



(a) Calculate the magnitude and direction of the velocity of the 2.0 kg cart after the collision.

(b) Calculate the mass m of the second cart.

After the collision, the second cart eventually experiences a ramp, which it traverses with no frictional losses. The graph below shows the speed v of the second cart as a function of time t for the next 5.0 s, where $t = 0$ is now the instant at which the carts separate.



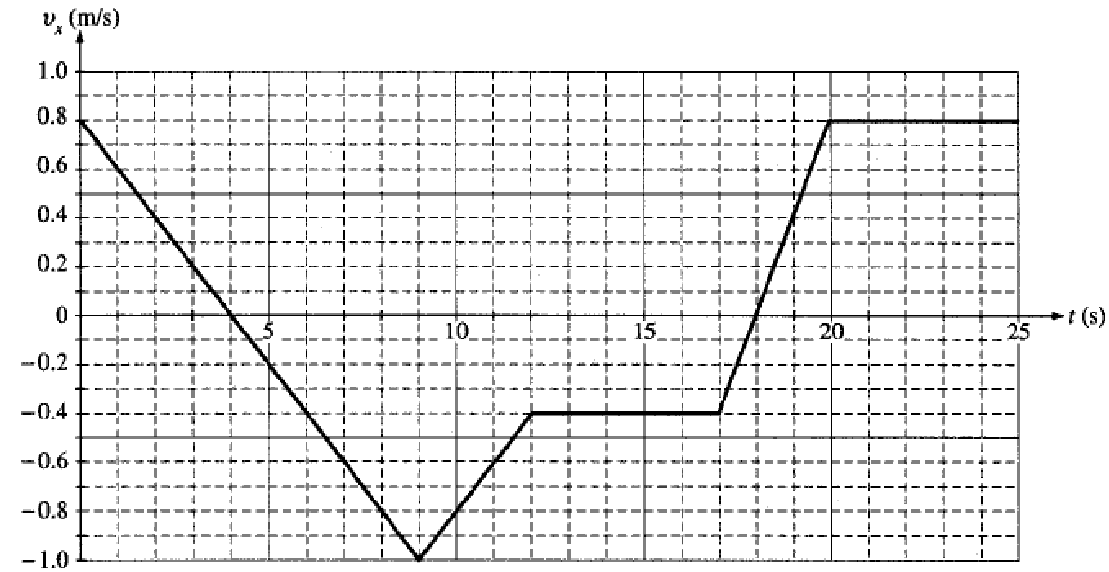
(c) Calculate the acceleration of the cart at $t = 3.0$ s.

(d) Calculate the distance traveled by the second cart during the 5.0 s interval after the collision ($0 \text{ s} < t < 5.0 \text{ s}$).

(e) State whether the ramp goes up or down and calculate the maximum elevation (above or below the initial height) reached by the second cart on the ramp during the 5.0 s interval after the collision ($0 \text{ s} < t < 5.0 \text{ s}$).

1. (15 points)

A 0.50 kg cart moves on a straight horizontal track. The graph of velocity v_x versus time t for the cart is given below.

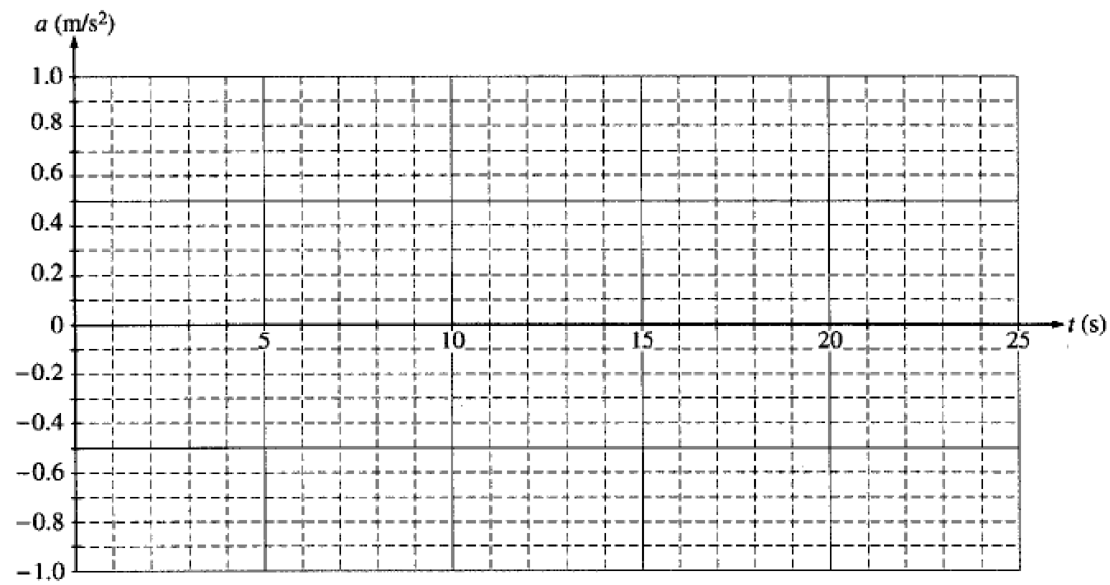


(a) Indicate every time t for which the cart is at rest.

(b) Indicate every time interval for which the speed (magnitude of velocity) of the cart is increasing.

(c) Determine the horizontal position x of the cart at $t = 9.0$ s if the cart is located at $x = 2.0$ m at $t = 0$.

(d) On the axes below, sketch the acceleration a *versus* time t graph for the motion of the cart from $t = 0$ to $t = 25$ s.

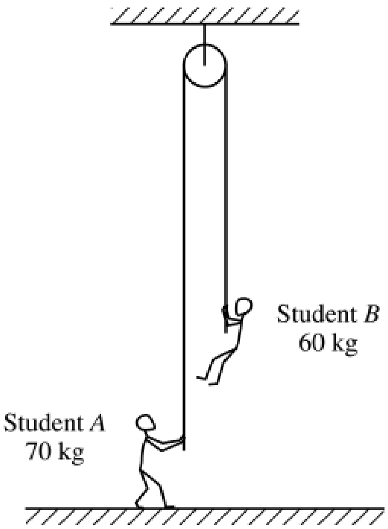


(e) From $t = 25$ s until the cart reaches the end of the track, the cart continues with constant horizontal velocity. The cart leaves the end of the track and hits the floor, which is 0.40 m below the track. Neglecting air resistance, determine each of the following.

i. The time from when the cart leaves the track until it first hits the floor

ii. The horizontal distance from the end of the track to the point at which the cart first hits the floor

iii. The kinetic energy of the cart immediately before it hits the floor



1. (15 points)
A rope of negligible mass passes over a pulley of negligible mass attached to the ceiling, as shown above. One end of the rope is held by Student *A* of mass 70 kg, who is at rest on the floor. The opposite end of the rope is held by Student *B* of mass 60 kg, who is suspended at rest above the floor.

(a) On the dots below that represent the students, draw and label free-body diagrams showing the forces on Student *A* and on Student *B*.

● *B*

● *A*

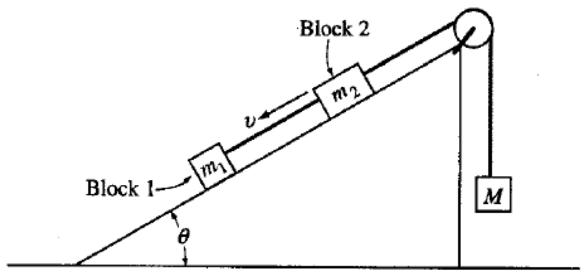
(b) Calculate the magnitude of the force exerted by the floor on Student *A*.

Student *B* now climbs up the rope at a constant acceleration of $0.25\ m/s^2$ with respect to the floor.

(c) Calculate the tension in the rope while Student *B* is accelerating.

(d) As Student *B* is accelerating, is Student *A* pulled upward off the floor? Justify your answer.

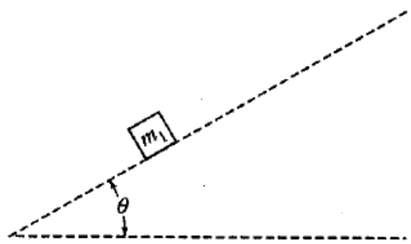
(e) With what minimum acceleration must Student *B* climb up the rope to lift Student *A* upward off the floor?



2. (15 points)

Blocks 1 and 2 of masses m_1 and m_2, respectively, are connected by a light string, as shown above. These blocks are further connected to a block of mass M by another light string that passes over a pulley of negligible mass and friction. Blocks 1 and 2 move with a constant velocity v down the inclined plane, which makes an angle θ with the horizontal. The kinetic frictional force on block 1 is f and that on block 2 is $2f$.

(a) On the figure below, draw and label all the forces on block m_1.



Express your answers to each of the following in terms of m_1, m_2, g, θ, and f.

(b) Determine the coefficient of kinetic friction between the inclined plane and block 1.

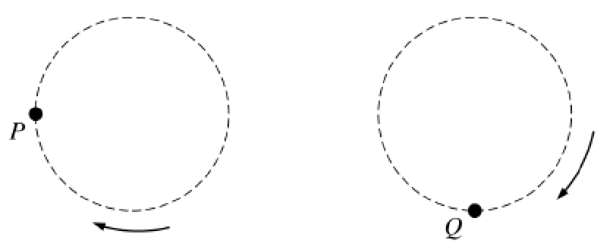
(c) Determine the value of the suspended mass M that allows blocks 1 and 2 to move with constant velocity down the plane.

(d) The string between blocks 1 and 2 is now cut. Determine the acceleration of block 1 while it is on the inclined plane.

1. (15 points)

A ball of mass M is attached to a string of length R and negligible mass. The ball moves clockwise in a vertical circle, as shown above. When the ball is at point P, the string is horizontal. Point Q is at the bottom of the circle and point Z is at the top of the circle. Air resistance is negligible. Express all algebraic answers in terms of the given quantities and fundamental constants.

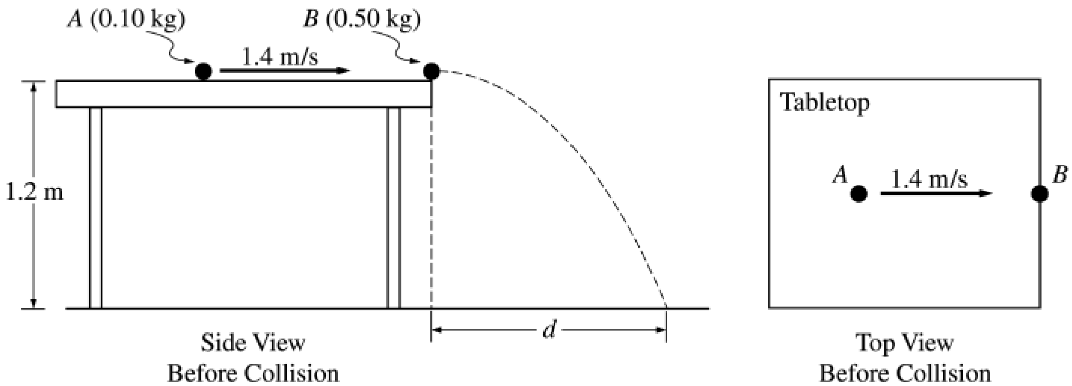
(a) On the figures below, draw and label all the forces exerted on the ball when it is at points P and Q, respectively.



(b) Derive an expression for v_{min}, the minimum speed the ball can have at point Z without leaving the circular path.

(c) The maximum tension the string can have without breaking is T_{max}. Derive an expression for v_{max}, the maximum speed the ball can have at point Q without breaking the string.

(d) Suppose that the string breaks at the instant the ball is at point P. Describe the motion of the ball immediately after the string breaks.



Note: Figures not drawn to scale.

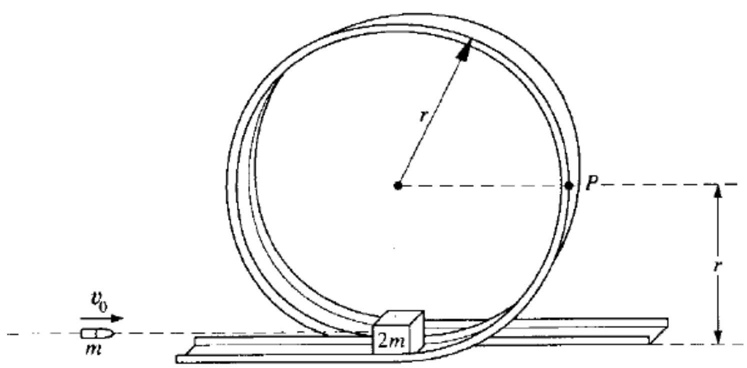
2. (15 points)

An incident ball A of mass 0.10 kg is sliding at 1.4 m/s on the horizontal tabletop of negligible friction shown above. It makes a head-on collision with a target ball B of mass 0.50 kg at rest at the edge of the table. As a result of the collision, the incident ball rebounds, sliding backwards at 0.70 m/s immediately after the collision.

(a) Calculate the speed of the 0.50 kg target ball immediately after the collision.

The tabletop is 1.20 m above a level, horizontal floor. The target ball is projected horizontally and initially strikes the floor at a horizontal displacement d from the point of collision.

(b) Calculate the horizontal displacement d.

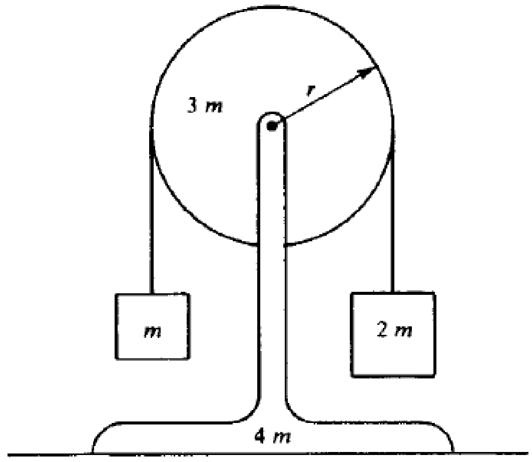


1. A small block of mass $2m$ initially rests on a track at the bottom of the circular, vertical loop-the-loop shown above, which has a radius r. The surface contact between the block and the loop is frictionless. A bullet of mass m strikes the block horizontally with initial speed v_0 and remains embedded in the block as the block and bullet circle the loop. Determine each of the following in terms of m, v_0, r, and g.

(a) The speed of the block and bullet immediately after impact

(b) The kinetic energy of the block and bullet when they reach point P on the loop

(c) The minimum initial speed v_{min} of the bullet if the block and bullet are to successfully execute a complete circuit of the loop



Mech. 3. A pulley of mass $3m$ and radius r is mounted on frictionless bearings and supported by a stand of mass $4m$ at rest on a table as shown above. The moment of inertia of this pulley about its axis is $\frac{3}{2}mr^2$. Passing over the pulley is a massless cord supporting a block of mass m on the left and a block of mass $2m$ on the right. The cord does not slip on the pulley, so after the block-pulley system is released from rest, the pulley begins to rotate.

(a) On the diagrams below, draw and label all the forces acting on each block.

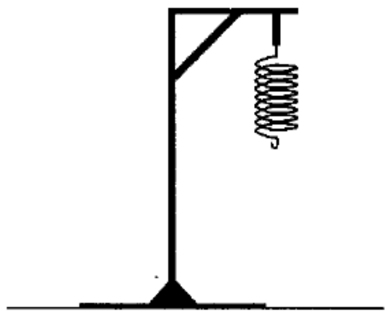
(b) Use the symbols identified in part (a) to write each of the following.

i. The equations of translational motion (Newton's second law) for each of the two blocks

ii. The analogous equation for the rotational motion of the pulley

(c) Solve the equations in part (b) for the acceleration of the two blocks.

(d) Determine the tension in the segment of the cord attached to the block of mass m.



2. (15 points)
A spring that can be assumed to be ideal hangs from a stand, as shown above.

(a) You wish to determine experimentally the spring constant k of the spring.

i. What additional, commonly available equipment would you need?

ii. What measurements would you make?

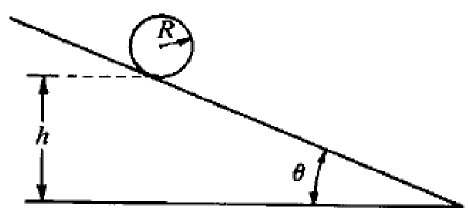
iii. How would k be determined from these measurements?

(b) Assume that the spring constant is determined to be 500 N/m. A 2.0-kg mass is attached to the lower end of the spring and released from rest. Determine the frequency of oscillation of the mass.

(c) Suppose that the spring is now used in a spring scale that is limited to a maximum value of 25 N, but you would like to weigh an object of mass M that weighs more than 25 N. You must use commonly available equipment and the spring scale to determine the weight of the object without breaking the scale.

i. Draw a clear diagram that shows one way that the equipment you choose could be used with the spring scale to determine the weight of the object.

ii. Explain how you would make the determination.



2. An inclined plane makes an angle of θ with the horizontal, as shown above. A solid sphere of radius R and mass M is initially at rest in the position shown, such that the lowest point of the sphere is a vertical height h above the base of the plane. The sphere is released and rolls down the plane without slipping. The moment of inertia of the sphere about an axis through its center is $\frac{2}{5}MR^2$. Express your answers in terms of M, R, h, g, and θ.

(a) Determine the following for the sphere when it is at the bottom of the plane.

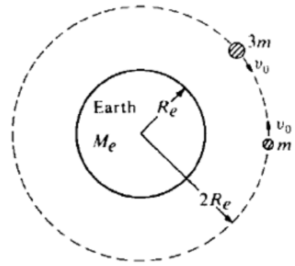
i. Its translational kinetic energy

ii. Its rotational kinetic energy

(b) Determine the following for the sphere when it is on the plane.

i. Its linear acceleration

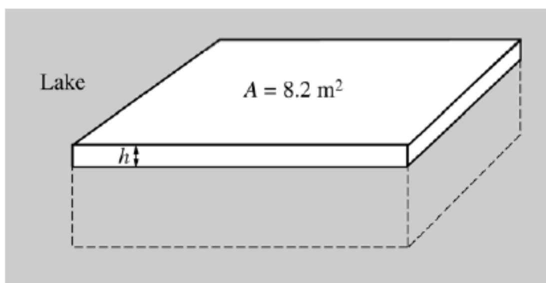
ii. The magnitude of the frictional force acting on it



2. Two satellites, of masses m and $3m$, respectively, are in the same circular orbit about the Earth's center, as shown in the diagram above. The Earth has mass M_e and radius R_e. In this orbit, which has a radius of $2R_e$, the satellites initially move with the same orbital speed v_0, but in opposite directions.

   (a) Calculate the orbital speed v_0 of the satellites in terms of G, M_e, and R_e.

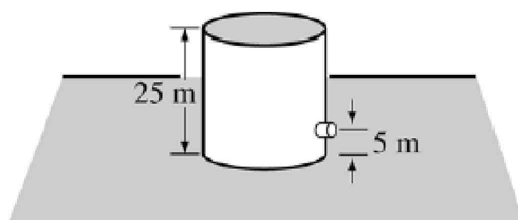
   (b) Assume that the satellites collide head-on and stick together. In terms of v_0, find the speed v of the combination immediately after the collision.



Note: Figure not drawn to scale.

A large rectangular raft (density 650 kg/m^3) is floating on a lake. The surface area of the top of the raft is 8.2 m^2 and its volume is 1.80 m^3. The density of the lake water is 1000 kg/m^3.

a. Calculate the height *h* of the portion of the raft that is above the surrounding water.
b. Calculate the magnitude of the buoyant force on the raft and state its direction.
c. If the average mass of a person is 75 kg, calculate the maximum number of people that can be on the raft without the top of the raft sinking below the surface of the water. (Assume that the people are evenly distributed on the raft.)



A large tank, 25 m in height and open at the top, is completely filled with saltwater (density 1025 kg/m^3). A drain plug with a cross-sectional area of 4.0×10^{-5} m^2 is located 5.0 m from the bottom of the tank. The plug breaks loose from the tank, and water flows from the hole.

a. Calculate the force exerted by the water on the plug before the plug breaks free.
b. Calculate the speed of the water as it leaves the hole in the side of the tank.
c. Calculate the volume flow rate of the water from the hole.