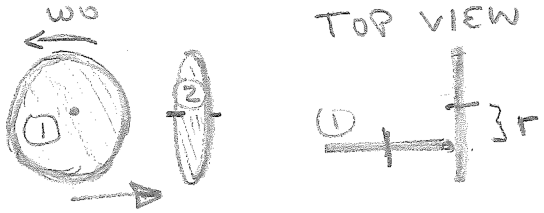
1. A frictionless firetruck sprays water at 45° from its on-board water tanks. The water lands a distance d away. (Assume resistance-free projectile motion.) Half of the initial mass of the truck is water. The water is sprayed at a rate k (mass per unit time.) What is the speed and position of the truck when it runs out of water?

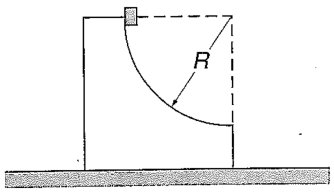
2. Ignore air resistance. A projectile is fired so that it should land on a target 200 m away on level ground. Unfortunately, it breaks into two equal mass pieces in flight. The pieces land at the same time, one 130 m away. Where does the other one land? Is your answer the same if they land at different times?

3. Use spherical coordinates to find the center of mass of a uniform solid hemisphere of radius R.

4.
Consider two wheels of equal radius R and mass m. One wheel is spinning with angular speed ω_0 about its axle. It is brought into perpendicular contact with the other (initially stationary) wheel at a distance r from the axle of the second wheel. When the slipping stops, how fast is each wheel spinning?



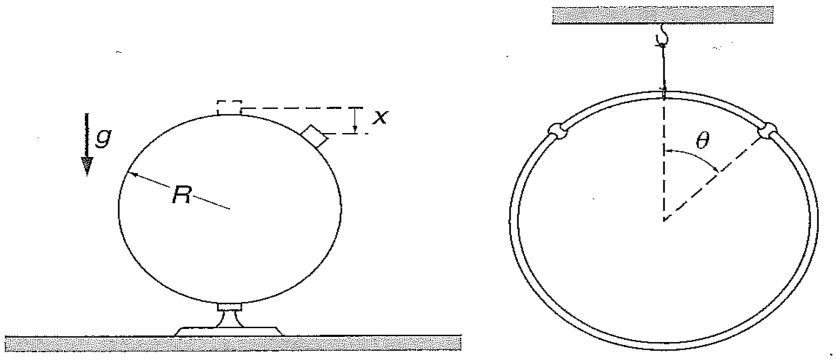
5.



5.4 *Sliding on a circular path**
A small cube of mass m slides down a circular path of radius R cut into a large block of mass M, as shown. M rests on a table, and both blocks move without friction. The blocks are initially at rest, and m starts from the top of the path.
Find the velocity v of the cube as it leaves the block.

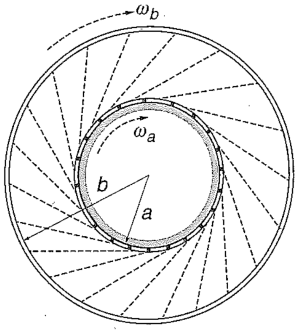
6.

5.6 *Block sliding on a sphere**
A small block slides from rest from the top of a frictionless sphere of radius R, as shown on the next page. How far below the top x does it lose contact with the sphere? The sphere does not move.



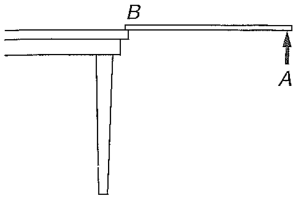
5.7 *Beads on hanging ring**

A ring of mass M hangs from a thread, and two beads of mass m slide on it without friction, as shown. The beads are released simultaneously from the top of the ring and slide down opposite sides. Show that the ring will start to rise if $m > 3M/2$, and find the angle at which this occurs.



7.2 *Drum and sand**

A drum of mass M_A and radius a rotates freely with initial angular speed $\omega_A(0)$. A second drum with mass M_B and radius $b > a$ is mounted on the same axis and is at rest, although it is free to rotate. A thin layer of sand with mass M_s is distributed on the inner surface of the smaller drum. At $t = 0$, small perforations in the inner drum are opened. The sand starts to fly out at a constant rate $dM/dt = \lambda$ and sticks to the outer drum. Find the subsequent angular velocities of the two drums ω_A and ω_B. Ignore the transit time of the sand.



7.14 *Stick on table**

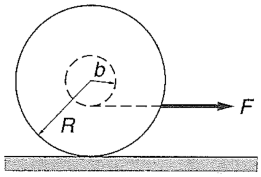
A uniform stick of mass M and length l is suspended horizontally with end B on the edge of a table, and the other end A is held by hand. Point A is suddenly released. At the instant after release:

(a) What is the torque around B?

(b) What is the angular acceleration around B?

(c) What is the vertical acceleration of the center of mass?

(d) From (c), find by inspection the vertical force at B.



7.27 *Yo-yo on table*

A yo-yo of mass M has an axle of radius b and a spool of radius R. Its moment of inertia can be taken to be $MR^2/2$. The yo-yo is placed upright on a table and the string is pulled with a horizontal force F as shown. The coefficient of friction between the yo-yo and the table is μ.

What is the maximum value of F for which the yo-yo will roll without slipping?

7.28 *Yo-yo pulled at angle*

The yo-yo of the previous problem is pulled so that the string makes an angle θ with the horizontal. For what value of θ does the yo-yo have no tendency to rotate?