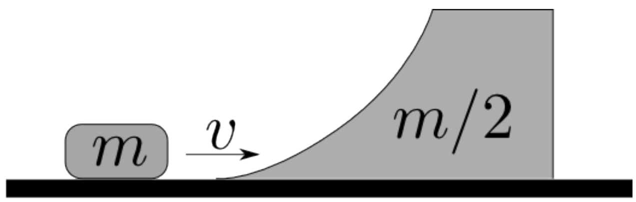
EXAM 1. Friday October 14, 9:10am – Monday, October 17, 9:10am

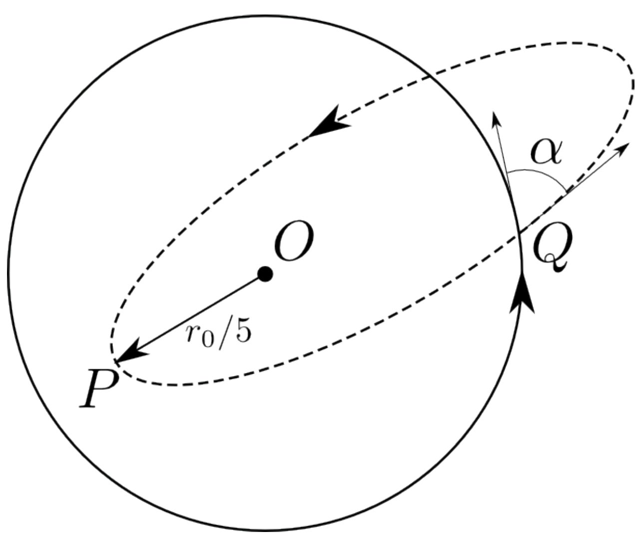
Problem 1. *1987-Fall-CM-U-1.*
A block of mass m slides on a frictionless table with velocity v. At $x = 0$, it encounters a frictionless ramp of mass $m/2$ which is sitting at rest on the frictionless table. The block slides up the ramp, reaches maximum height, and slides back down.

1. What is the velocity of the block when it reaches its maximum height?
2. How high above the frictionless table does the block rise?
3. What are the final velocities of the block and the ramp?



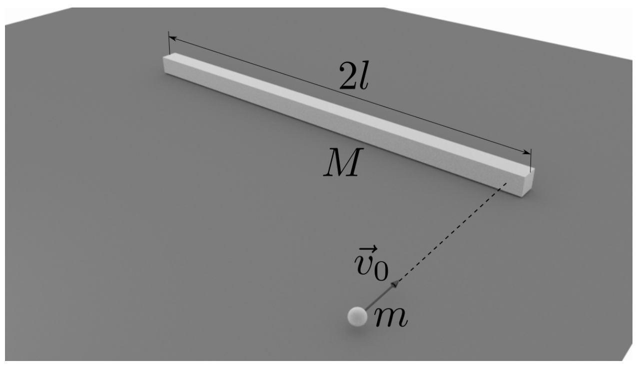
Problem 2. *1993-Fall-CM-U-1*
A satellite of mass m is traveling at speed v_0 in a circular orbit of radius r_0 under the gravitational force of a fixed mass M at point O. At a certain point Q in the orbit (see the figure below) the direction of motion of the satellite is suddenly changed by an angle α without any change in the magnitude of the velocity. As a result the satellite goes into an elliptic orbit. Its distance of the closest approach to O (at point P) is $r_0/5$.

1. What is the speed of the satellite at P, expressed as a multiple of v_0?
2. Find the angle α.



Problem 3. *1995-Spring-CM-U-3*

A uniform line-like bar of mass M, and length $2l$ rests on a frictionless, horizontal table. A point-like particle of mass $m \ll M$ slides along the table with velocity v_0 perpendicular to the bar and strikes the bar very near one end, as illustrated below. Assume that the force between the bar and the particle during the collision is in the plane of the table and perpendicular to the bar. If the interaction is elastic (*i.e.*, if energy is conserved) and lasts an infinitesimal amount of time, then determine the rod's center-of-mass velocity V and angular velocity ω, and the particle's velocity v after the collision.

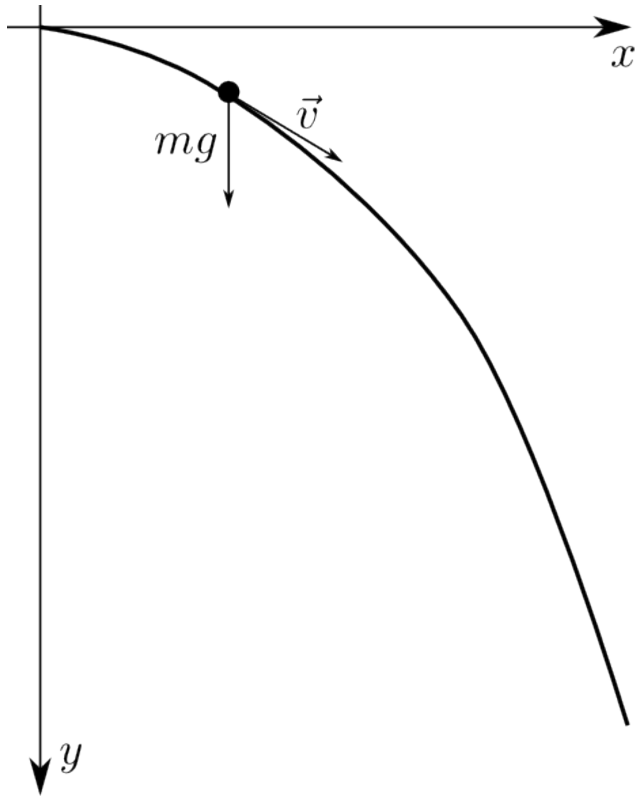


Problem 4. *1996-Fall-CM-U-2*

A particle of mass m slides down a curve $y = kx^2$, ($k > 0$) under the influence of gravity, as illustrated. There is no friction, and the particle is constrained to stay on the curve. It starts from the top with negligible velocity.

1. Find the velocity (vector!) $\vec{v}$ as a function of x. (use the system of coordinates shown in the figure.)

2. Next, assume that the particle initially slides down the curve under gravity, but this time it is only supported (but not constrained) by the curve. Does it leave the curve after it has slid a certain distance? Prove your answer.


x
$\vec{v}$
mg
y