

PHY 111: Mechanics
School of Physics, IISER Thiruvananthapuram
Varsha, 2013

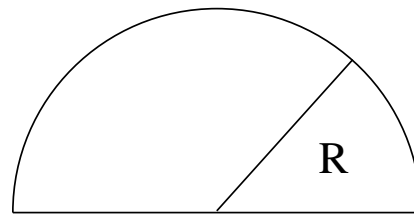
Problem Set 2; Due: Aug 26, 2013

Note: The due date for returning the solutions is as mentioned. Please try to work out the problems by yourself (discuss with your friends if necessary). Please resist the temptation to 'google out' the answers. You stand to gain a lot by attempting to solve on your own.

1. **Mission unsuccessful:** An instrument carrying projectile accidentally explodes at the top of its trajectory. The horizontal distance between the launch point and the point of explosion is L . The projectile breaks into two pieces which fly apart horizontally. The larger piece has three times the mass of the smaller piece. To the surprise of the scientist in charge, the smaller piece returns to earth at the launching station. How far away does the larger piece land? Neglect air resistance and effects due to curvature of the earth.



Problem 2



Problem 3

2. **Spring and blocks:** A system is composed of two blocks of mass m_1 and m_2 connected by a massless spring with spring constant k . The blocks slide on a frictionless plane. The unstretched length of the spring is l . Initially m_2 is held so that the spring is compressed to $l/2$ and m_1 is forced against a stop as shown in figure. m_2 is released at $t = 0$. Find the motion of the center of mass of the system as a function of time.
3. **Center of mass:** Find the center of mass of a half-circular sheet of radius R and uniform surface mass density of ρ_0 . (see Figure.)
4. **Leaky car:** A freight car of mass M contains sand of mass m . At $t = 0$, a constant horizontal force F is applied in the direction of rolling and at the same time a hole in the bottom of the car opens up which leaks sand out at constant rate of dm/dt . Find the speed of the freight car when all the sand is gone. Assume the freight car is at rest at $t = 0$ and there is no friction.
5. **Varsha season:** A bowl full of water is sitting out in a pouring rainstorm. Its surface area is 500 cm^2 . The rain is coming straight down at 5 m/s at a rate of $10^{-3} \text{ g}/(\text{cm}^2 \cdot \text{s})$. If the excess water drips out of the bowl with negligible velocity, find the force on the bowl due the falling rain. What is the force if the bowl is moving uniformly upward at 2 m/s ?

6. **Rocket science:** A rocket ascends from rest in a uniform gravitational field by ejecting exhaust with constant speed u . Assume that the rate at which mass is expelled is given by $dm/dt = \gamma m$, where m is the instantaneous mass of the rocket and γ is a constant. The rocket is resisted by air resistance with a force mbv , where b is constant and v is the instantaneous velocity. Find the velocity of the rocket as a function of time.

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