

**2002-2003 Physics Olympiad Preparation Program**  
**- University of Toronto -**  
**Problem Set 2: Mechanics**  
**Due: 9 December 2002**

1. A cylinder of radius  $R$  and mass  $M$  rolls down an incline as shown in Figure 1. It starts from rest. What is the cylinder's acceleration  $a$ ? What is the minimum coefficient of static friction  $\mu_s$  that is required for the cylinder to roll down the incline without slipping?
2. Four planets, each of mass  $M$ , are at the corners of a square, the sides of which are length  $L$ . At what speed  $v$  must the planets move so that they maintain a circular orbit that circumscribes the square?
3. An object consists of two identical masses  $m$  joined by a weightless rod of length  $L$ . It collides elastically with a mass  $2m$ . See Figure 2. How does the system evolve?
4. A gas of molecules exerts a pressure  $P$  on the walls of a closed box. A small hole is created in one side of the box. Estimate the speed  $v$  with which the molecules exit the box.
5. Blow up a balloon B1. Insert one end of a plastic drinking straw into the mouth of B1. Tie down the mouth of B1 to the straw. Do not allow any air to escape through the open end of the straw. Blow up a second balloon B2 with a smaller volume than B1. Insert the open end of the straw into the mouth of B2. Tie down the mouth of B2 to the straw, but do not allow any air from B2 into the straw. Now allow the system to equilibrate. What happens to the balloons? Explain your observations.

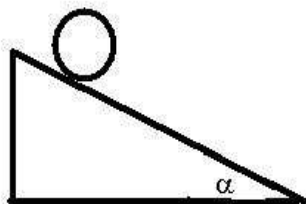


Figure 1

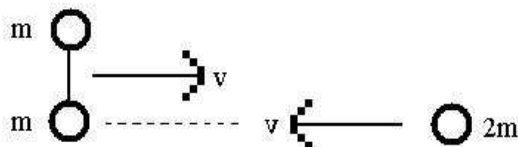


Figure 2