Lansing Area High School Physics Competition

Problem Set 2

Opening date: December 9th, 2002.
Due date: January 15th, 2003.
Send solutions by mail to:
LAHSPC, Department of Physics, MSU, East Lansing, MI 48824
For more details see: `www.pa.msu.edu/~nagy_t/lahspc/lahspc.html`

P11. A long tree trunk is pulled slowly by an ox. We would like to measure the length of the trunk, but the ox doesn't want to stop. It takes 17 steps from one end of the trunk to the other end when we move with the trunk. When we move in the opposite direction it takes 12 steps. How many steps long is the trunk? (Assume that all the steps are equal in length and each step takes the same amount of time.)

(3 points)

P12. A very light but solid rod of length $l = 2$ m is suspended at the midpoint M and can rotate without friction. A small but heavy ring R slides freely on the rod, and is initially at a distance of $l/4$ from the end. (See Figure 1.) The rod is then released from this horizontal position. Describe what happens. (Hint: Neglect the mass of the rod.) What is the speed of the rod's end point when the rod goes through its vertical position?

(4 points)

P13. If a flea can jump vertically to a height of one meter, then how far at most can it jump horizontally? At what angle with respect to the horizontal should it jump in order to reach this maximum distance? (Neglect air resistance.)

(5 points)

P14. A pendulum of length l is suspended from point P. (See Figure 2.) It is held in a horizontal position, and then released. As it swings, it hits a nail N which is exactly under the suspension point at a distance of $l/2$. The bob then travels along a circular path with radius $l/2$. How high will it rise on this path? Will it reach the suspension point? Or will it leave the circular orbit sooner? If yes, where?

(5 points)

P15. A coin is lying on a horizontal surface which oscillates vertically with a constant amplitude A but with a slowly increasing angular frequency ω. At what frequency does the coin start bouncing on the surface?

(3 points)

P16. How much time would it take for the Earth to hit the Sun if the Earth suddenly stopped on its orbit around the Sun?

(5 points)

P17. A large ice cube floats in water in a beaker. What happens to the water level after the ice cube melts if there is **(a)** a steel ball, **(b)** an air bubble, **(c)** a wood ball, **(d)** a hydrogen bubble in the ice? Explain your answers.

(3 points)

P18. A sailboat travels on the surface of Lake Michigan. The wind speed is 10 m/s. The force on the sail is proportional to the square of the relative windspeed, and the coefficient is $k_1 = 64\ \mathrm{Ns^2/m^2}$. The drag force on the body of the boat under the water is proportional to the square of the boat speed, and the coefficient is $k_2 = 4\ \mathrm{Ns^2/m^2}$. What is the speed of the boat after long time?

(4 points)

P19. We have a battery with electromotive force $\mathcal{E}$ and internal resitance r. What external resistor R should we connect to the battery, if we want the maximum possible power on this resistor? What is the efficiency in this case? What external resistor should we use in order to reach 100 percent efficiency? How much power do we get out of the battery in this case?

(5 points)

P20. On a clear winter day the shadows on the white snow look slightly blue. Why?

(3 points)

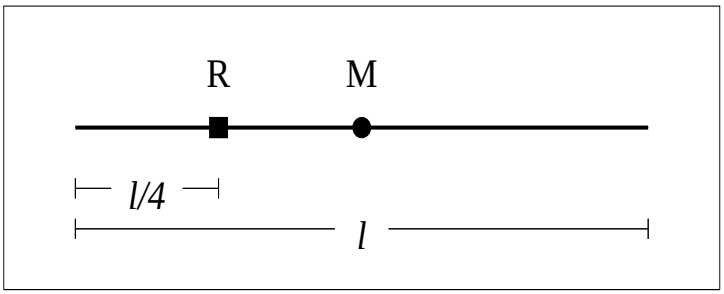

Figure 1: Problem P12.

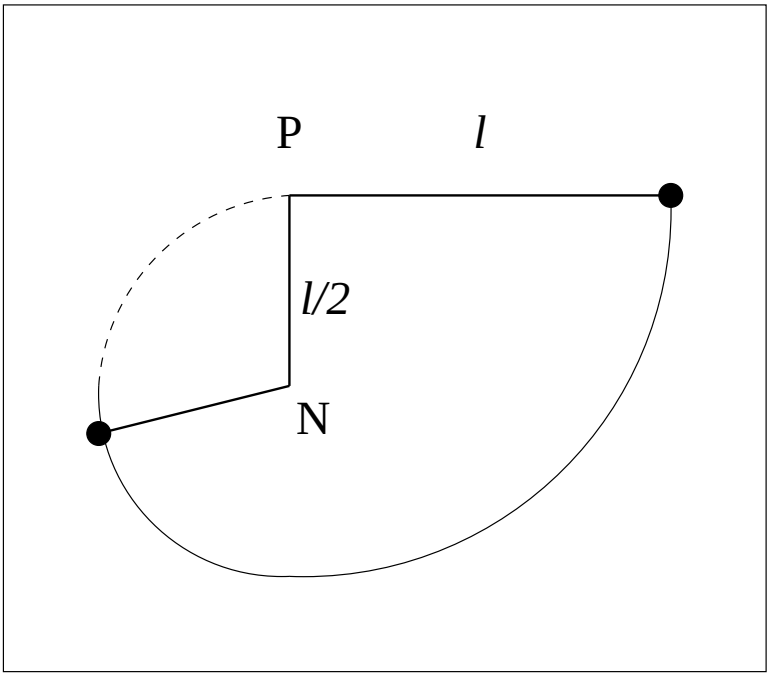

Figure 2: Problem P14.