1. A particle initially sits on top of a large smooth sphere of radius R. The particle begins to slide down the sphere, without friction. At what angular position will the particle lose contact with the surface of the sphere? Where will the particle land? (H. C. Ohanian, "Physics" Pr. 7.55)

2. A windmill for the generation of electric power has a propeller of diameter 1.8 m. In a wind of 40 km/h, this windmill delivers 200 W of electric power.

   (a) At this wind speed, what is the rate at which the air carries kinetic energy through the circular area swept out by the propeller? The density of air is 1.29 kg/m^3.

   (b) What percentage of the kinetic energy of the air passing through this area is converted into electric energy?
   (H. C. Ohanian, "Physics" Pr. 8.61)

3. The reaction that supplies the Sun with energy is

   $$H + H + H + H \rightarrow He + energy$$

   (The reaction involves several intermediate steps, but this need not concern us now.) The mass of the hydrogen (H) atom is 1.00813 u and that of the Helium (He) is 4.00388 u.

   (a) How much energy is released in the reaction of four hydrogen atoms (by conversion of rest mass into energy)

   (b) How much energy is released in the reaction of 1 kg of hydrogen atoms?

   (c) The sun releases energy at the rate of 3.9×10^{26} W. At what rate (in kg/s) does the Sun consume hydrogen?

   (d) The Sun contains about 1.5×10^{30} kg of hydrogen. If it continues to consume hydrogen at the same rate, how long will the hydrogen last?
   (H. C. Ohanian, "Physics" Pr. 8.67)

4. If an artificial satellite, or some other body, approaches a moving planet on a hyperbolic orbit, it can gain some energy from the motion of the planet and emerge with a larger speed than it had initially. This slingshot effect gas been used to boost the speeds of the two Voyager spacecraft as they passed near Jupiter. Suppose that the line of approach

of the satellite makes an angle θ with the line of motion of the planet and the line of recession of the satellite is parallel to the line of motion of the planet. The speed of the planet is u and the initial speed of the satellite is v (in the reference frame of the sun).

(a) Show that the final speed of the satellite is

$$v' = u + \sqrt{v^2 + u^2 - 2uv\cos\theta}$$

(b) Show that the satellite will not gain any speed in this encounter if $\theta = 0$ and show that the satellite will gain maximum speed if $\theta = \pi$.

(c) IF a satellite with $v = 3\ km/s$ approaches Jupiter at an angle of $\theta = 20°$, what will be its final speed?
(H. C. Ohanian, "Physics" Pr. 9.48)