1. What horizontal force is required to keep a 1000 kg car moving South at a constant 100 km/hr on a level road in Albuquerque? How about East? What are the answers if you are at the equator? **Ignore friction and air resistance.**

2. A small toy car begins accelerating along a radius of a large turntable rotating at 1 rad/s. The car accelerates at 1 m/s^2. The coefficient of friction is 0.4.

a) When does the car begin to slip? (Solve the problem with variables first, then substitute numbers at the end.)

b) What is your answer if every number given is doubled?

c) For part a, Sketch the path of the car, as seen from an inertial (non-rotating) observer. You don't need to be precise about the path, but the place where it slips you can be precise with. Also, sketch roughly the path after it starts slipping. (Note that the coefficient of sliding (kinetic) friction is not zero.)

3. A mass m coasts along the x-axis with a retarding drag force F = -cv$^{3/2}$. Separate variables in F=ma and find v(t) and then x(t). Does it ever stop? How far does it go?

4. Sprinkler problem. You are to design a hemispherical sprinkler head. Water comes out of small holes distributed over the head. Each mini-jet comes out at the same speed v. Your job is to tell the machinist how many holes to put at each polar angle θ to ensure even watering within a circular area. Treat each jet as a frictionless projectile.

5.

Consider an object that is thrown vertically up with initial speed v_o in a linear medium. **(a)** Measuring y *upward* from the point of release, write expressions for the object's velocity $v_y(t)$ and position $y(t)$. **(b)** Find the time for the object to reach its highest point and its position y_{max} at that point. **(c)** Show that as the drag coefficient approaches zero, your last answer reduces to the well-known result $y_{max} = \frac{1}{2}v_o^2/g$ for an object in the vacuum. [*Hint:* If the drag force is very small, the terminal speed is very big, so v_o/v_{ter} is very small. Use the Taylor series for the log function to approximate $\ln(1+\delta)$ by $\delta - \frac{1}{2}\delta^2$.]

Assignment continues on next page.

2-11. Consider a particle of mass m whose motion starts from rest in a constant gravitational field. If a resisting force proportional to the square of the velocity (i.e., kmv^2) is encountered, show that the distance s the particle falls in accelerating from v_0 to v_1 is given by

$$s(v_0 \rightarrow v_1) = \frac{1}{2k} \ln \left[\frac{g - kv_0^2}{g - kv_1^2} \right]$$

2-12. A particle is projected vertically upward in a constant gravitational field with an initial speed v_0. Show that if there is a retarding force proportional to the square of the instantaneous speed, the speed of the particle when it returns to the initial position is

$$\frac{v_0 v_t}{\sqrt{v_0^2 + v_t^2}}$$

where v_t is the terminal speed.

2-14. A projectile is fired with initial speed v_0 at an elevation angle of α up a hill of slope $\beta (\alpha > \beta)$.

(a) How far up the hill will the projectile land?

(b) At what angle α will the range be a maximum?

(c) What is the maximum range?

2-19. If a projectile moves such that its distance from the point of projection is always increasing, find the maximum angle above the horizontal with which the particle could have been projected. (Assume no air resistance.)