

Ph1a - Flipped Section

Problem Set 4

October 17, 2019

1. Hands on Astrophysics

The Sun is about 25,000 light years from the center of the galaxy and travels approximately in a circle with a period of 1.7×10^8 years. The Earth is 8 light minutes away from the Sun and also goes in an approximate circular orbit. From this data alone, find the approximate gravitational mass of the galaxy in units of the Sun's mass. You may assume that all the relevant galactic mass for the gravitational force on the Sun is located at the center of the galaxy.

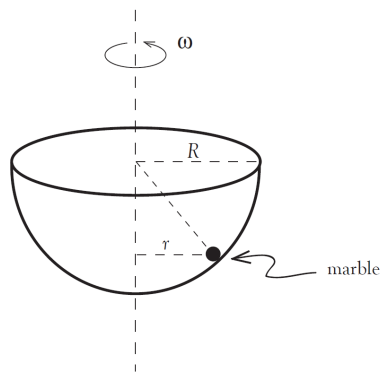
2. Driving on a curved road

A circular curved road with radius of curvature R is banked at an angle θ . The coefficient of static friction between car tires and the road is μ . Ignore torques on the car.

- What is the maximum speed v at which you can drive?
- Suppose that, on a rainy day, your coefficient of friction becomes $\mu' = \frac{1}{2}\mu$. What is the maximum speed at which you can drive now?

3. Marble in a bowl

A marble of mass m is deposited inside a hemispherical bowl of radius R , as shown in the figure. The bowl is then spun around its vertical axis with a constant angular velocity ω . The marble eventually settles at a distance r from the bowl's vertical axis while rotating around that axis with the same angular velocity ω as the bowl itself.



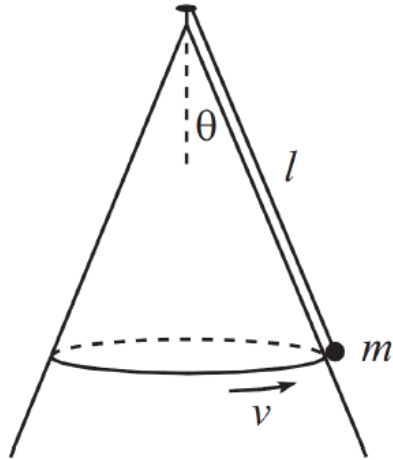
- Find the force that the bowl exerts on the marble. Give the total magnitude of the force as well as its angle with respect to the vertical axis of the bowl.
- Derive an expression for r in terms of R , ω , and the gravitational acceleration g .

Note that, for small enough ω , the answer to part (b) does not make sense.

- Explain what happens physically when the angular velocity ω is too small.

4. Circling around a cone

(Morin, Introductory Mechanics, Problem 4.24)



A mass m is attached by a massless string of length l to the tip of a frictionless cone. The half-angle at the vertex of the cone (angle between edge and central axis) is θ . If the mass moves around in a horizontal circle at speed v on the cone, find:

- the tension in the string,
- the normal force from the cone,
- the maximum speed v for which the mass stays in contact with the cone.