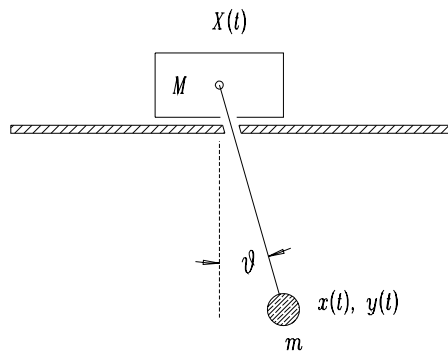


PHYS 321 Homework Assignment #7
Due: Friday, 7 November 2002

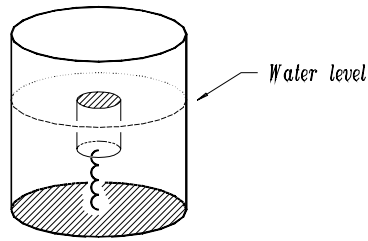
Make sure to read Chapter 7 of Barger & Olsson.

1. The system shown below consists of a block of mass M that can slide without friction, in the x -direction along a horizontal air track. A pendulum hangs from a pivot attached to the block, in such a way that it swings in the $x-y$ plane ($y = \text{vertical}$). The pendulum consists of a massless rod of (fixed) length r and a bob of mass m .



Write the Lagrangian of the system in terms of the coordinates $\theta(t)$ (the angle of the rod relative to the vertical) and $X(t)$ (the position of the block along the air track). Derive the equations of motion. Find the constants of the motion (there are two of them.) Solve the equations of motion, assuming θ is “small”, in the usual sense, and thereby determine the frequencies of oscillation of the system. Are the motions of block and pendulum independent?

2. A beaker of water has a cork in it, held partially submerged by a stretched spring attached to the bottom, as shown below.

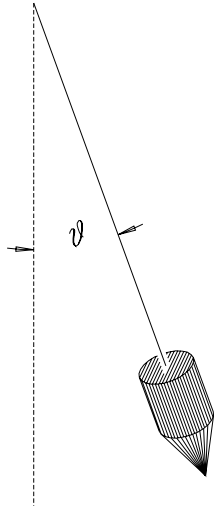


If the beaker is dropped, what happens to the cork, relative to the bottom of the beaker?

- a) It does not move. (The distance to the bottom remains unchanged.)
- b) It rises higher relative to the surface of the water. (The distance to the bottom increases.)
- c) It sinks. (The distance to the bottom decreases.)

Explain your answer. A letter indicating an outcome is an insufficient answer, be it never so correct.

3. A beaker of water at the surface of the Earth spins about its axis of symmetry (locally vertical axis!) with angular velocity ω . Find the effective potential experienced by a test particle in the beaker's rest frame (this is *not* an inertial frame), and hence find the equation of the water's surface.
4. A suspended plumb bob is used to indicate the local direction of gravity, as shown below.



Imagine two situations:

- a) you are in a train going up a 30° grade at the Earth's surface;
- b) the train is moving on the level but accelerating at $g/\sqrt{3}$ along the track.

Either situation will cause the bob to deviate from the vertical (relative to the car) by 30° . Devise a simple experiment using the plumb bob that can discriminate between the two cases, without looking out of the train windows.

5. Problem 7-1 on p. 278 in Barger & Olsson.
6. Problem 7-9 on p. 279. (Imagine the object is a hockey puck on very smooth ice, on the surface of a very large Canadian lake in midwinter.)