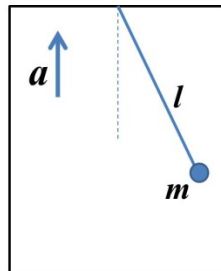


95.413/513. Classical Mechanics.  
Second Midterm Exam.  
Nov. 26, 2013 (Open book exam)

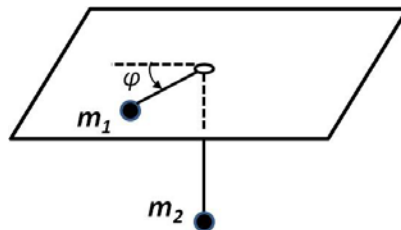
1. (10 points)

A simple pendulum of mass  $m$  and length  $l$  suspended from the ceiling of an elevator is accelerating upward with acceleration  $a$ . Find the frequency of small oscillations. (Derive the equation of motion from scratch using Newton's 2<sup>nd</sup> law)



2. (10 points)

An inextensible massless string of length  $l$  passes through a hole in a frictionless table. A point mass  $m_1$  at one end moves on the table and a point mass  $m_2$  hangs from the other end. Assume that  $m_2$  moves in a vertical line only.



- Write the Lagrangian of the system.
  - Find the equations of motion.
  - Under what condition will the hanging mass  $m_2$  remain stationary ( $m_1$  undergoes circular motion)?
  - Assume that the hanging mass is pulled down slightly from the stationary position and released. What is the frequency of small oscillations about the circular motion?
3. (10 points)
- Assume that the speed of light in media is proportional to the height. Show that light moves in circular arcs in this media. Assume that Fermat's principle of least time works.