

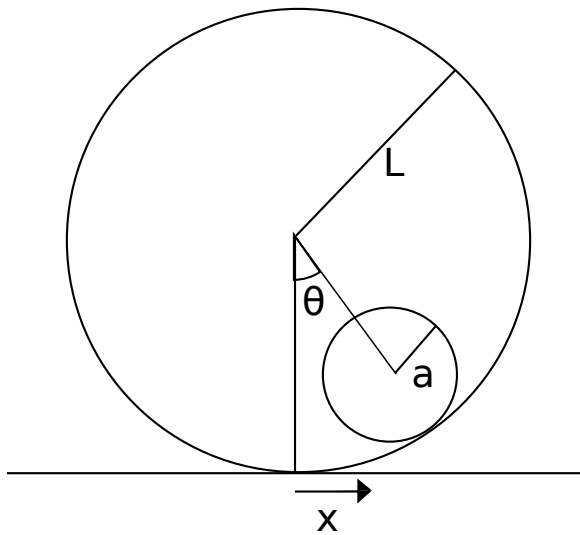
Physics 321 | Fall 2012

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Midterm 2

This test is open book and open note. Do not use any other resources (classmates, friends, internet, other books). You may use Mathematica (or another CAS). Please show your work and explain your reasoning.

1. A cylinder of mass  $m$  and radius  $a$  rolls inside a circular pipe of mass  $M$  and radius  $L$  without slipping. The pipe rolls on a planar surface without slipping.



Use the angle  $\theta$  and the displacement of the pipe  $x$  as the generalized coordinates (see figure).

- a) Draw a velocity diagram for each component of the system.
- b) What is the kinetic energy of the system?
- c) What is the potential energy of the system?
- d) What is the Lagrangian for the system?
- e) What are the equations of motion for the system?

Assume that the pipe doesn't roll.

- f) What is the Hamiltonian for the system?
  - g) What are the Hamiltonian equations of motion?
2. Problem 14.6 (remember to use velocity diagrams and be careful calculating the Hamiltonian).