

Physics 504a

Problem set #1, due Wednesday, September 12, 2007

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1. Problem Goldstein 1-5.
2. Problem Goldstein 1-14.
3. Problem Goldstein 1-15. [Hint: You could select  $\vec{\sigma}$  to be in the z-direction.]
4. Two masses  $M$  and  $m$  are connected by a weightless string of length  $\ell$ , which passes through a hole in a smooth horizontal table. The mass  $M$  is limited to move on the top surface of the table. The other mass  $m$  hangs suspended and moves freely under the table. (Assume that neither  $M$  nor  $m$  passes through the hole.) a) Find the Lagrangian and write down the Lagrange equations of this system. b) Find two constants of motion, which correspond to the azimuthal angles. Write down explicitly the equations of motion for the two remaining variables.
5. Problem Goldstein 1-22.
6. A particle of mass  $m$ , released from rest at a time  $t = 0$ , falls vertically under the influence of gravity. It is also subject to a vertical **frictional** force  $Q$ , which is proportional to the **square** of the vertical speed of the falling mass. Find the equation of motion by using the Lagrange equation in the form of

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) - \frac{\partial L}{\partial q} = Q.$$

Solve the equation of motion and find the speed and the height of the mass  $m$  at a subsequent time  $t$ . What is the terminal speed?