University of California at Berkeley *Spring Semester 2003*
Department of Mechanical Engineering *Name:*

ME 104 Engineering Mechanics II - Test 2

1. (28+8 points) Consider the motion of a particle B of mass m inside a smooth hollow pipe that is rotating with constant angular velocity $\boldsymbol{\omega} = \omega_0 \mathbf{k}$ about a vertical axis. The particle is connected to a linear spring (spring constant k and unstretched length r_0), and is initially released at $r = r_0$ with no radial velocity. The position vector of the particle is given by $\mathbf{r} = r\,\mathbf{e}_r + z_0\,\mathbf{k}$, where z_0 is constant. **NOTE**: In parts (b) and (f) k is zero; in other parts it is non-zero.

(a) Draw the free-body diagram of B and write down the component forms of Newton's 2nd law.

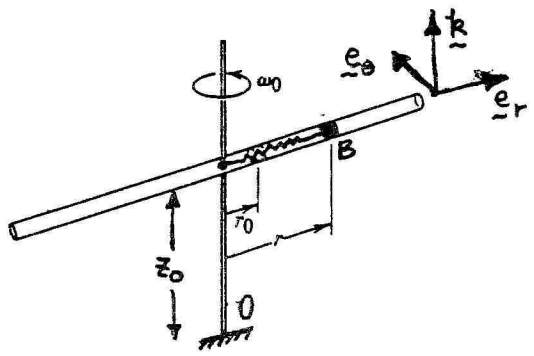
(b) For the case $k = 0$, there are no radial forces acting on B since this corresponds to the spring being absent. Show that the radial velocity increases with time even though there are no radial forces. Provide a brief explanation.

(c) Determine the total contact force $\mathbf{C}$ exerted by the pipe on B as a function of r.

(d) Show that the component of $\mathbf{C}$ in the plane of motion is expressible as a cross-product $2m\,\boldsymbol{\omega} \times \mathbf{v}_{B/\text{pipe}}$, where $\mathbf{v}_{B/\text{pipe}} = v_r\,\mathbf{e}_r$ is the velocity of B relative to the rotating pipe. This force is called the Coriolis force.

(e) Does the contact force $\mathbf{C}$ do any work? Justify your answer by computing the work term.

(f) (8 points) EXTRA CREDIT. For $k = 0$, solve for the radial coordinate as a function of time. Do this part only after attempting all other problems. No partial credit for part (f).



2. (22 points) The 3-kg block A is released from rest in the position shown and subsequently strikes the stationary 1-kg cart B. If the coefficient of restitution for the collision is $e = 0.7$, determine the maximum displacement s of the cart beyond point C. Neglect friction and assume that all motion occurs in the vertical plane.