ME 115(a): Homework #4

(Due Wednesday, February 22, 2012)

Problem #1: (15 points) Next quarter we will extensively study the problem of grasping–
i.e., how one can grab an object with fingers in such as way as to prevent the grasped object
from slipping out of the grasp. Consider the arrangement in Figure 1 where a planar disc
is touched by 3 "planar" fingers. Assume that each finger touches the disc with *frictionless*
point contact. Also assume that each finger can apply any possible force to the object.

Question: Is the disc immobilized? That is, are there any free motions of the disc that can
not be prevented by the fingers? In addition to an intuitive discussion of this question, you
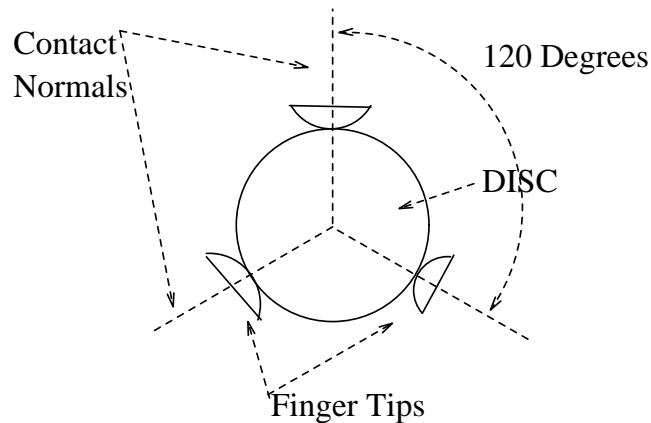must back up your answer with some analysis.

Figure 1: Grasp of a disc by frictionless fingers

Problem #2: (15 points)

Assume that the orientation of a rigid body is described by z-y-z Euler angles, where the
angles of rotation are respectively ψ, ϕ, and γ. Further assume that the body is spinning
with rotation rates of $\dot{\psi}$, $\dot{\phi}$, and $\dot{\gamma}$ about the respective z, y, and z axes. Show that the spatial
angular velocity of the body is:

$$\vec{\omega}^s = \begin{bmatrix} -\dot{\phi}\sin\psi + \dot{\gamma}\cos\psi\sin\phi \\ \dot{\phi}\cos\psi + \dot{\gamma}\sin\psi\sin\phi \\ \dot{\psi} + \dot{\gamma}\cos\phi \end{bmatrix} \tag{1}$$

Note that the solution to this problem is useful for the study of gyroscopes.

Problem #3: (10 points) Problem 13 in Chapter 2 of MLS.

Problem #4: (10 points) Problem 14 in Chapter 2 of MLS.

Problem #5: (10 points) Problem 15 in Chapter 2 of MLS.

Problem #6: (15 points) Problem 18(c,d,e) in Chapter 2 of MLS.