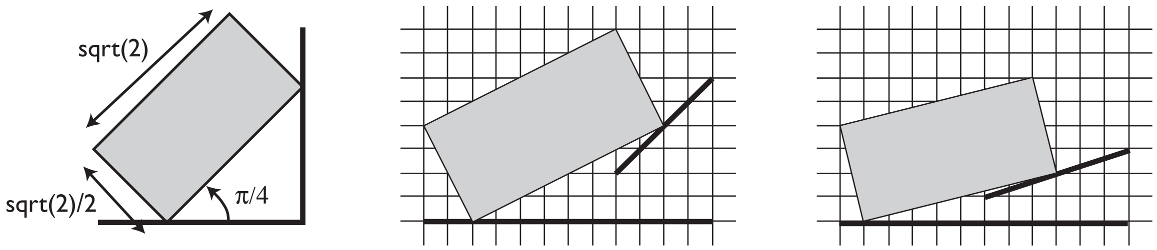
CSCI 4961/6961 Advanced robotics, Spring 2000
Assignment 2, out 1/26/00, due 2/2/00

1. In the diagrams below, a rectangular block is tilted so that one corner contacts the support surface and the other corner contacts a wall (figure (a)) or a "palm" (figures (b) and (c)).

   (a) For figure (a), what is the minimum coefficient of friction (μ) required in order for the block to remain in equilibrium, i.e./ not slip? Although it is possible to solve this part using a free body diagram, you should use friction cones and arguments about resultant forces in order to develop insight that will make the rest of this problem simple.

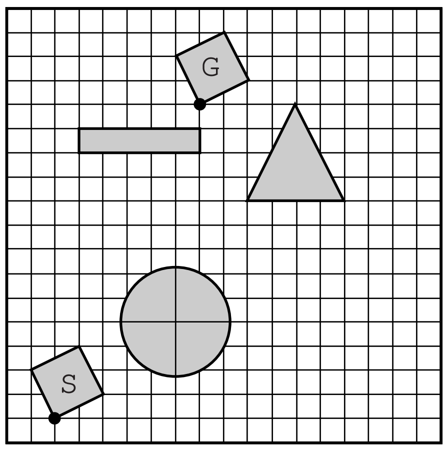
   (b) For figure (b), assume that the coefficient of friction is $\frac{1}{4}$. Does the object slip or remain in equilibrium? Justify your answer.

   (c) For figure (c), assume that the coefficient of friction between the block and the support surface is $\frac{1}{3}$, but that we have replaced the palm material so that the coefficient of friction between it and the object is $\frac{3}{4}$. We will slowly move the palm to the right. Will the object move with the palm[1] or will it slide off? Justify your answer. You should assume quasistatic manipulation.



(a) (b) (c)

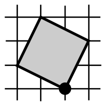
2. The figure below shows a (tilted) square robot in a room with some obstacles. The start configuration is in the lower left corner, the goal configuration is at the top. The reference point of the robot is indicated with the black dot.



[1] i.e. the corner on the palm stays fixed with respect to the palm and the corner on the support surface slides

(a) Construct the two dimensional configuration space for this robot and draw the shortest path from the start to the goal. Assume the orientation of the robot is fixed.

(b) Do the same for the orientation of the robot shown below. Assume that this is the orientation of the robot at the start and the goal.



3. We often use polygonal models in robotic motion planning, so one important algorithm is determining whether two polygons intersect. Assume you are given two simple convex polygons. Give an algorithm (in pseudocode) to determine whether they intersect or not and perform an analysis of its running time.

4. Suppose we apply the A* algorithm to planning a path on a graph using a uniform approximate cell decomposition, i.e. we divide each axis of configuration space into divisions of size s, thus creating uniform cells covering the region of interest in configuration space. We create a graph connecting all completely empty cells and seach it using the A* algorithm. Assume we use straight line Euclidean distance as our heuristic function.

   What is the running time in terms of s (and anything else you need to describe the running time)? Explain your work. This is a somewhat open-ended question, so be sure to describe assumptions you make (and possibly their limitations).