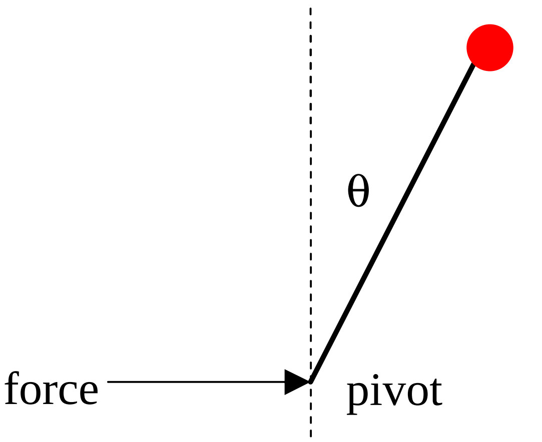
CSG2341 Intelligent Systems

Module 3: Inverted Pendulum Problem

This is an example of a control problem for which we can create a fuzzy controller. Although this is not very useful in real life, it shows the principles of fuzzy control.

Have you ever balanced a broom/golf club etc by holding it upside down on the flat of your hand? If not, try it. The broom (or other object) will start to fall to one side, but you can keep it upright by moving your hand sideways.

We are going to use a simplified model of the balancing broom. This kind of model is sometimes called an *inverted pendulum.* Our model is illustrated in the diagram below:



The model is in 2 dimensions. The broom is modelled as a massless rigid pole 1m long, with a 1kg mass attached at the top. The pole is supported from below at the pivot, and a force can be applied to the right or left at that point. The angle between the pole and the vertical (in radians) is called θ (theta). If the pole leans to the right, theta is positive.

In order to keep the pole balanced, the force must be varied taking into account theta, as well as the rate of change or theta (i.e. the pole may be leaning to the right but rotating toward the left). A maximum force of about 1.5 newtons should be enough to keep the pole balanced.

For those who are interested, I have used the following equations to model the dynamics of this system:

$$m\ddot{x} - mL\sin(q)\dot{q}^{2} + mL\cos(q)\ddot{q} = F$$

$$mL\cos(q)\ddot{x} + mL^{2}\ddot{q} - mgL\sin(q) = 0$$

where *m* is the mass, *L* is the length, *x* is the horizontal position, *g* is acceleration due to gravity (9.8 m/s^2) and *F* is the force.

For those who'd rather not know, I have implemented this model in a set of Java classes that we can use to create and test a controller for this system (see eCourse).