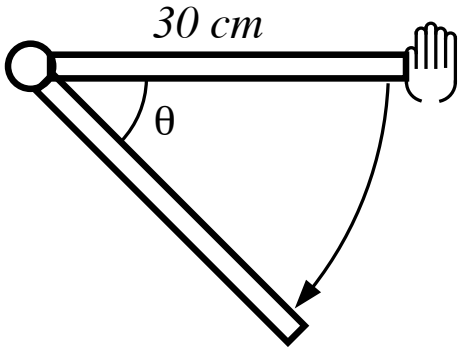
6. (8 points) A worker has to tighten a bolt using a wrench. She holds the wrench 30 cm away from the bolt. The more she tightens the bolt, the more force she has to use. The force she applies is equal to $3 + \tan^2 \theta$ newtons, where $\theta$ is the angle between the original position of the wrench and the current position, in radians.

   How much work does she do to turn the bolt $1/8$ of a full turn (that is, $\pi/4$ radians)?

   Give your answer in joules (1 joule = 1 newton-meter).

   (Hint: The distance traveled along a circle of radius $r$ in moving an angle of $\Delta\theta$ radians is $r\Delta\theta$.)



6. (8 points) Hooke's law states that the force required to maintain a spring stretched $x$ units beyond its natural length is proportional to $x$. The work required to stretch the spring from 2 feet beyond its natural length to 4 feet beyond its natural length is 18ft-lb. How far beyond its natural length can the spring be stretched with a force not exceeding 24 pounds?

8. (10 total points) A spring has a natural length of 10 cm. The spring is now allowed to hang vertically, with the top end attached to a rigid support and the other end attached to a mass of 1 kg. This causes the spring to stretch 3 cm, to a length of 13 cm.

   (a) (4 points) Find the spring constant $k$. The acceleration due to gravity is 9.8 $\mathrm{m/sec}^2$.

   (b) (6 points) A small child pulls down on the mass, stretching the string to 15 cm. How much work does the child do?