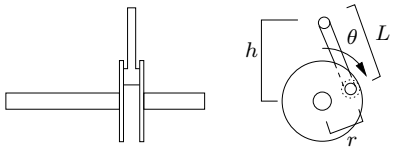
3. [10 points] For each of the following determine the indicated quantity.

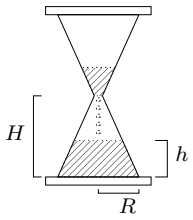
a. [4 points] In an internal combustion engine, pistons are pushed up and down by a crank shaft similar to the diagram shown to the right. As the shaft rotates the height of the piston, h, is related to the rotational angle θ of the shaft by $h = r\cos\theta + \sqrt{L^2 - r^2\sin^2\theta}$, where r and L are constant lengths. If $r = 10$ cm, $L = 15$ cm, and h is decreasing at a rate of 5000 cm/s when $\theta = 3\pi/4$, how fast is θ changing then?

Crank shaft diagram (part a)



side view end view

Hourglass diagram (part b)



b. [6 points] The lower chamber of an hourglass is shaped like a cone with height H in and base radius Rin, as shown in the figure to the right, above. Sand falls into this cone. Write an expression for the volume of the sand in the lower chamber when the height of the sand there is h in *(Hint: A cone with base radius r and height y has volume $V = \frac{1}{3}\pi r^2 y$, and it may be helpful to think of a difference between two conical volumes.)*. Then, if $R = 0.9$ in, $H = 2.7$ in, and sand is falling into the lower chamber at $2\,\text{in}^3/\text{min}$, how fast is the height of the sand in the lower chamber changing when $h = 1$ in?