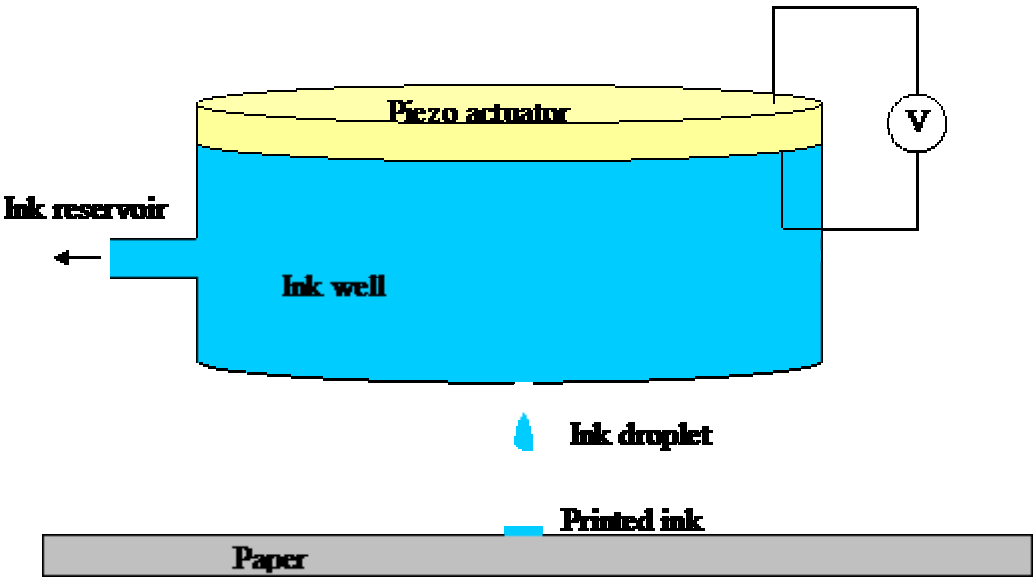
Practice problem

The figure below shows a schematic of a simplified model of an inkjet printer head that uses piezoelectric actuation. It consists of a PZT disk of diameter 2000 um, and thickness 10 um. The disk is fixed to a frame at the top. The ink-well is below the bottom surface. If this were to print with 600 dpi (dots per inch) resolution with the printed film thickness of 2 um, determine the value of the voltage to be applied to the PZT disk. The piezoelectric coefficient relating the strain in the thickness direction of the disk and the voltage applied is 480E-12 m/V.



First, let us calculate the volume of the droplet ejected out of the ink well each time the piezoactuator is supplied with a voltage pulse. Assuming circular drops printed on the paper, the print resolution of 600 dpi means that there will be 600 circular dots per in. That is the diameter of a single dot is 1/600 in = 0.0017 in = 42.3 um. Since the printed film is 2 um thick, the volme of the droplet is

$$\frac{\pi(42.3E-6)^2}{4}(2E-6)=2.8106E-15\ m^3.$$

To eject a droplet of this volume, the PZT disk must displace along the longitudinal axis by δ, which is given by

$$\delta=\frac{\text{volume of the droplet}}{\text{area of c/s of the ink well}}=\frac{2.8106E-15}{\pi(2E-3)^2/4}=8.9464E-10\,m$$

Since the thickness of the PZT disk is 10 um, the strain in the longitudinal axis of the disk is given by

$$\in=\frac{\delta}{L}=\frac{8.9464E-10}{10E-6}=8.9464E-5$$

Noting the relationship between the voltage per unit length and the strain, $vd=\in$ where $d=480E-12\,m/V$, the required voltage is given by

$$v = \frac{\in}{d} = \frac{8.9464E-5}{480E-12} = 1.8638E5V/m$$

For a thickness of 10um, the required voltage to be applied on the disk is $1.8638 \approx 1.86V$.