$$\omega_n^2 = (2\pi(2500))^2 = 2.47\times10^8 \ s^{-2}$$

$$T(s) = \frac{\frac{\omega_n}{Q}s + \omega_n^2}{s^2 + \frac{\omega_n}{Q}s + \omega_n^2} = \frac{448.8\,s + 2.47\times10^8}{s^2 + 448.8s + 2.47\times10^8}$$

1 4. $F = \frac{\varepsilon_0 \varepsilon_r A V^2}{2d^2} = \frac{(8.854\times10^{-12})(1)(500\times10^{-6})^2(100)^2}{2(10\times10^{-6})^2} = 110.675\,\mu N$

2 8. since $\omega >> \omega_n$, use $V = V_{rms}$

$$\therefore F = \frac{\varepsilon_0 \varepsilon_r A V_{rms}^2}{2d^2} = \frac{(8.854\times10^{-12})(1)(500\times10^{-6})^2(100)^2}{(2)(2)(10\times10^{-6})^2} = 55.34\,\mu N$$

3 6. $V_p = \sqrt{\frac{8kd^3}{27A\varepsilon_0\varepsilon_r}}$

$$= \sqrt{\frac{8(50)(10\times10^{-6})^3}{27(500\times10^{-6})^2(8.854\times10^{-12})(1)}}$$

$$= 81.81\,V$$

$$F = \frac{\varepsilon_0 \varepsilon_r A V^2}{2(d-x)^2}$$

$$= \frac{(8.854\times10^{-12})(1)(500\times10^{-6})^2(81.81)^2}{2\left[\frac{2}{3}(10\times10^{-6})\right]^2}$$

$$= 166.67\,\mu N$$

4 1. $\alpha = (\Delta L/L)/T$

$\Delta L = \alpha L \Delta T = (2.6\times10^{-6})(500\times10^{-6})(100) = 1.3\times10^{-7}\,m = 0.13\,\mu m$

$L_{new} = L + \Delta L = 500 + 0.13 = 500.13\,\mu m$

5 2. $L_{new} = L + \Delta L$

$= L + \alpha L \Delta T$

$= L(1 + \alpha \Delta T)$

$= 500\times10^{-6}[1 + (25\times10^{-6})(100)] = 5.0125\times10^{-4}\,m = 501.25\,\mu m$

6 3. a. Electrostatic

b. Thermal Bimorph

c. Piezoelectric

d. SMA

e. FlowFET

f. Thermal Pump

g. Magnetic

7 4. $d = aS$

$= \frac{a}{\omega_n^2}$

$= \frac{10(9.8)}{(2\pi(800))^2}$

$= 3.88\times10^{-6}\,m$

$= 3.88\,\mu m$