

Answer all 5 questions.

1. Answer based on very general scaling laws:
  - a) Why it is challenging to build nano/microrobots?
  - b) Why capacitive coupling may actually be quite an appropriate method in length scales below 10  $\mu\text{m}$ ?
  - c) What is meant by high surface area material? Give some rough numbers what it means.
  
2. Mechanical force is given by  $F = -kx$ . The force related to the electrostatic energy  $E = \frac{1}{2} CU^2$ , where  $C = \epsilon A / (d_0 - x)$  is given by  $F = -\partial E / \partial x$  (assume one-dimensional case).  $U$  is voltage and  $d_0$  is the equilibrium distance.
  - a) Show where the mechanical actuation, the real motion comes from in a capacitive coupled system
  - b) Derive the pull-in point and the corresponding voltage (only correct answer without derivation gives 0 points)
  
3. Explain the concepts Johnson-Nyquist, 1/f noise and thermal noise
  
4.
  - a) Explain the working principle of PCR chips
  - b) Explain a system and methods to sort various kinds of cells from a liquid channel using optics
  
5. Design a microsystem that can be used (choose only one, explain the method and give some estimated performance numbers)
  - a) to measure the speed of wind
  - b) to measure relative humidity
  - c) to measure angular velocity
  - d) as a reference oscillator at 900 MHz for mobile phones