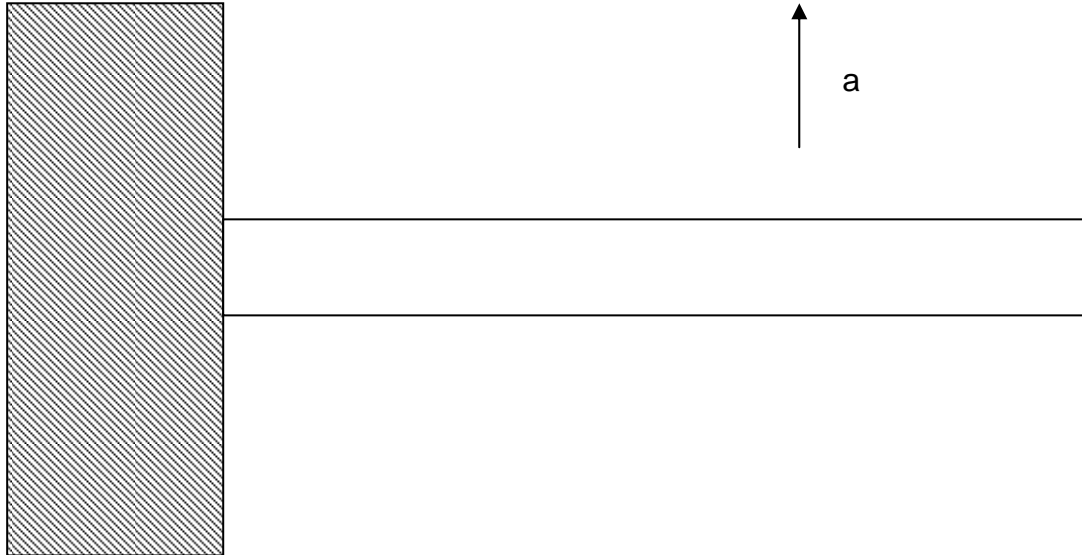Exercise 4 for FYS4230 Microsystem modeling
Piezoresistors on a bending beam

A fixed –free beam experiences an acceleration a=50g (g is the acceleration of gravity) so that it bends downwards.
Sideview:

The dimensions of the beam: The length is L=3mm, the thickness is h=8 micrometers and the width w=50 micrometer. The normal stresses on normal sections of a beam were found in exercise 1 (the exercise about beam bending).

The beam itself is micromachined in an n-type, (100) silicon wafer. The beam is parallel to the <110> flat.

A p-type piezoresistor is implanted and diffused from the top side of the beam. The piezoresistor is 0.2 micrometer deep, 5 micrometer wide and 50 micrometer long. If the piezoresistor is parallel with the beam length direction

   a) Where would you place the piezoresistor in order to obtain a maximum sensitivity? Notation: the piezoresistor starts at a distance s from the beam end.

Top view, beam with piezoresistor, conductors and bonding pads:
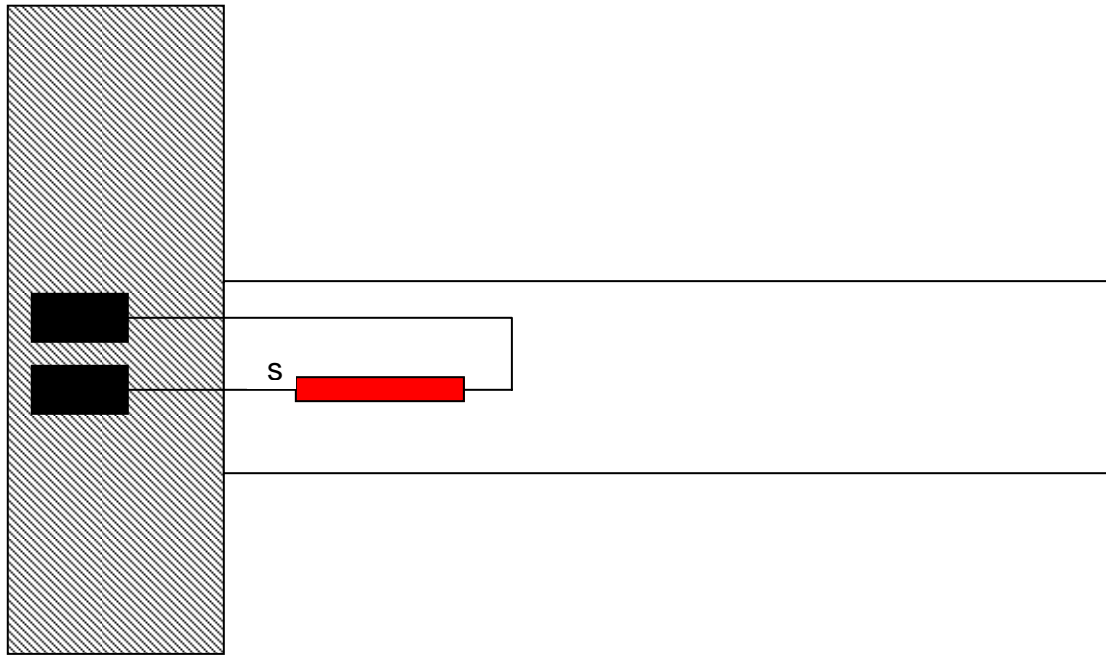
b) Explain why the mean value of the normal stress in the piezoresistor can be described by:

$$\overline{\sigma} = \frac{1}{10(\mu m)^2} \int\limits_{3.8\,\mu m}^{4\,\mu m} \int\limits_{s\mu m}^{s+50\,\mu m} \frac{1}{2}z(x^2 - 2Lx + L^2)\frac{12 \cdot 50\rho Lbhg}{Lbh^3}\,dxdz$$

Without calculating this integral, which value of the normal stress would you pick as an approximate mean value for the whole piezoresistor?

c) The n-type beam is connected to the potential V=0. Should the potential of the p-type circuit be positive or negative relative to this voltage?

d) The gauge factor for the piezoresistor is given by:

$$\frac{\Delta R}{R} = \pi_l\sigma_l + \pi_t\sigma_t$$

The resistivity of the piezoresistor is 7.8Ω-cm. Find the values for the longitudinal and transverse piezocoefficients. And then the gauge factor for the beam when it bends out with the acceleration.

e) Suggest an alternative positioning of the piezoresistor (disregard space needed for conductor lines). Will the gauge factor increase or decrease?

f) If you place two piezoresistors on the beam and connect them in a half-bridge in the optimal way, find an expression for the bridge output V_0.

g) How would you suggest optimizing this piezoresistive accelerometer? How could you improve the sensitivity?