UNIVERSITÄT SIEGEN
FESTKÖRPERPHYSIK

Crystallography (*winter term 2015/2016*)

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<u>**Exercise sheet 4: Crystals morphology**</u>

1. ''Two-dimensional crystals'' morphologies (4 points)

Index (find the Miller indices of) all the faces of the two-dimensional crystal forms, shown in the Figures 1ab. *Hint: Choose any appropriate pair of basis vectors and follow the indexing algorithm, outlined in the lectures.*

2. Three-dimensional ''cubic'' crystal morphologies (5 points)

Rhombic dodecahedron is one possible shape of a cubic ($a = b = c$, $\alpha = \beta = \gamma = 90°$) crystal, consisting of the {110} types faces (12 faces all together, see the Figure 2). Calculate the angles between the adjacent faces of a rhombic dodecahedron. How do these angles change if one of the lattice parameters elongates by 10 % ?

3. Three-dimensional ''cubic'' crystal morphologies (4 points)

Index (write down the Miller indices) all the faces of the three-dimensional polyhedron shapes of a cubic crystal in the Figures 3-5. *Hint: Draw the reciprocal basis vectors and recognize (visually) the directions of the normal to all faces. Try to recognize the faces, which belong to a) cube {100}; b) octahedron {111}; c) rhombic dodecahedron {110}*

4. Equilibrium shapes of crystals: Gibbs principle and Wulff theorem (4 points).

A cubic (a = b = c, α = β = γ = 90°) crystal starts growing from a *seed crystal*, which has {100} and {110} faces only. The shape of the seed is displayed in the Figure 4. The specific *surface energies* of the {100} and {110} types of faces are σ_1 and σ_2 correspondingly ($\sigma_1 < \sigma_2$). Which maximum value may the ratio σ_2/σ_1 reach so that the equilibrium (according to the Wulff theorem) shape of the crystal keeps the same number of faces as the seed crystal.

5. Equilibrium shapes of crystals: Gibbs-Wulff principle (4 points).

The same as the task 4 but for the {110} and {111} faces (Figure 5)

Hint to the tasks 4-5: The Gibbs principle prescribes the equilibrium crystal shape, for which the entire surface energy $\sum_i \sigma_i S_i$ reaches the minimum for a fixed volume of a crystal. Wulff showed that this condition can be converted into the following geometrical constraint:

$$\frac{\sigma_i}{D_i} = const$$

where σ_i is the specific surface energy of the faces; D_i is the distance from the faces to the centre of the crystal.

Please return on 23/11/2015

Figure 1a (for the task 1)

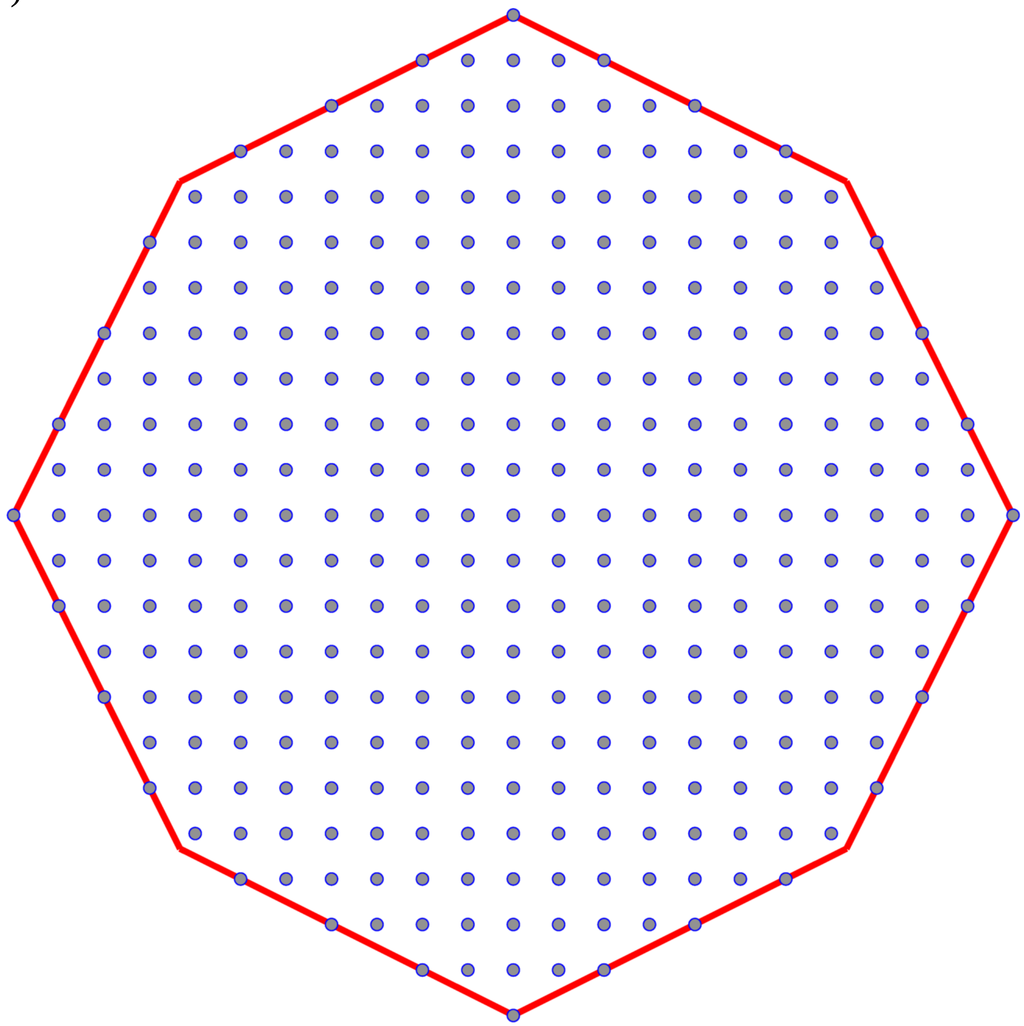


Figure 1b (for the task 1)

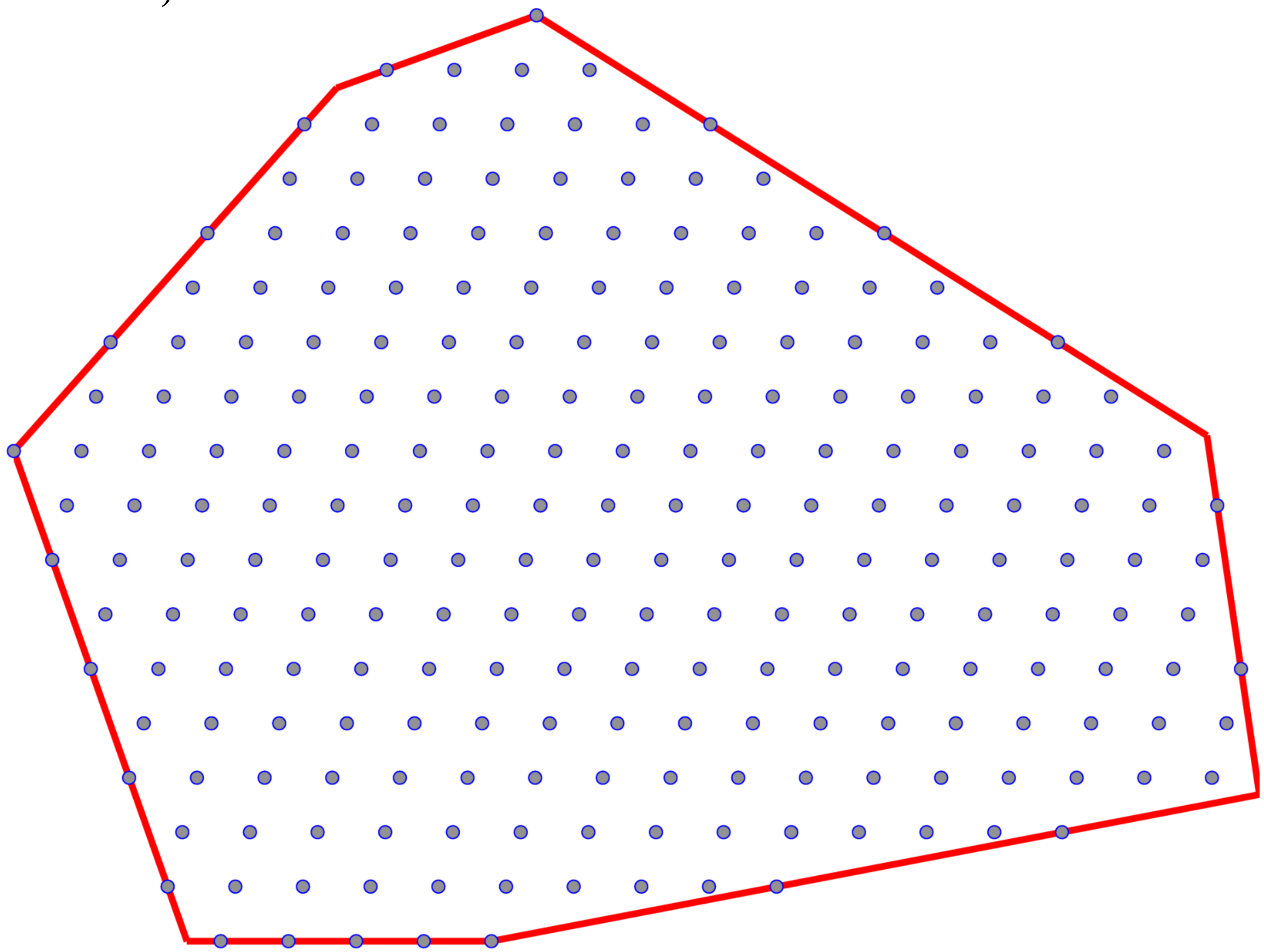


Figure 2 (for the task 2)

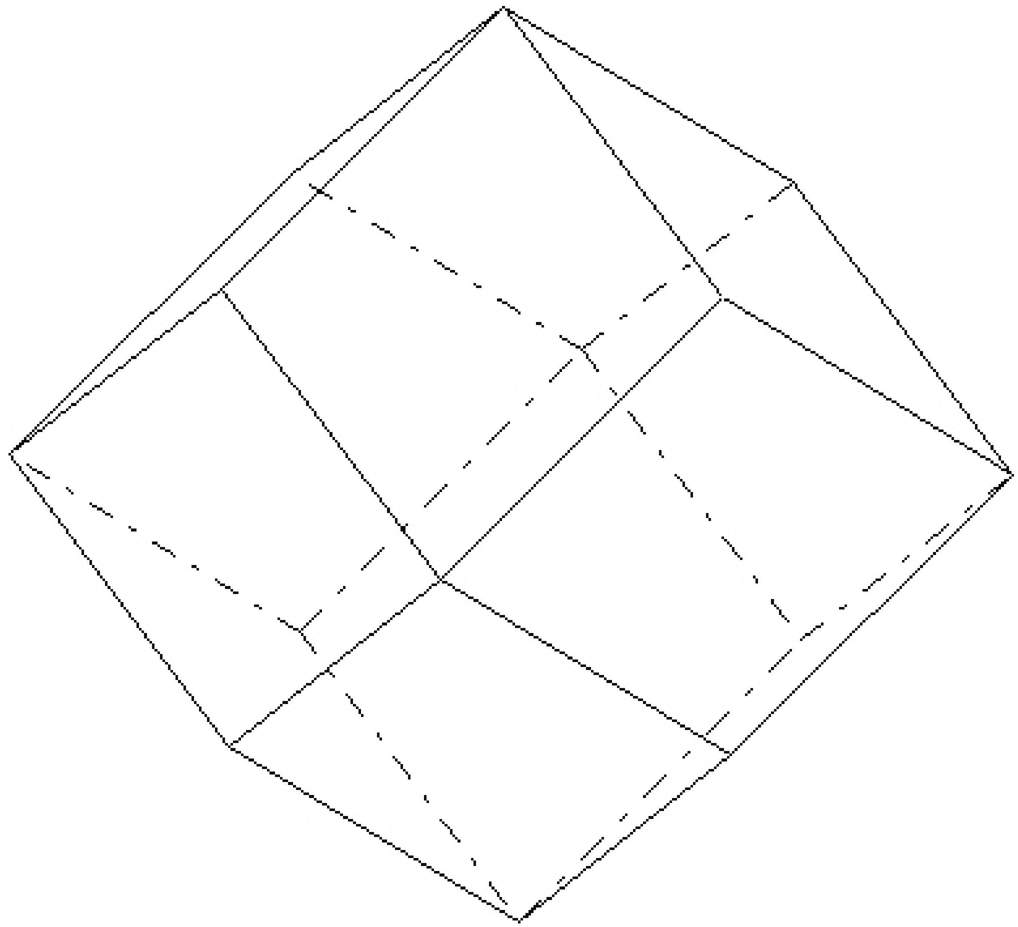


Figure 3 (for the task 3)

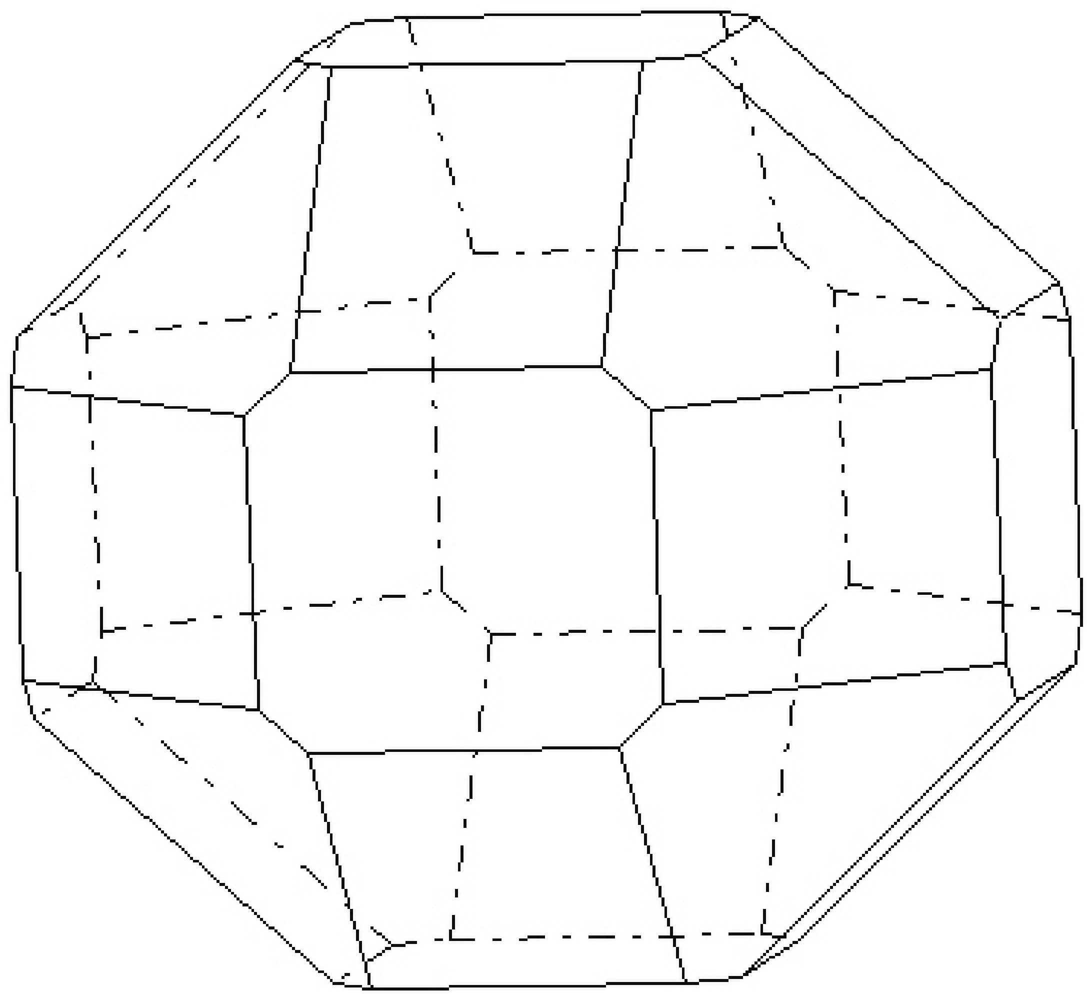
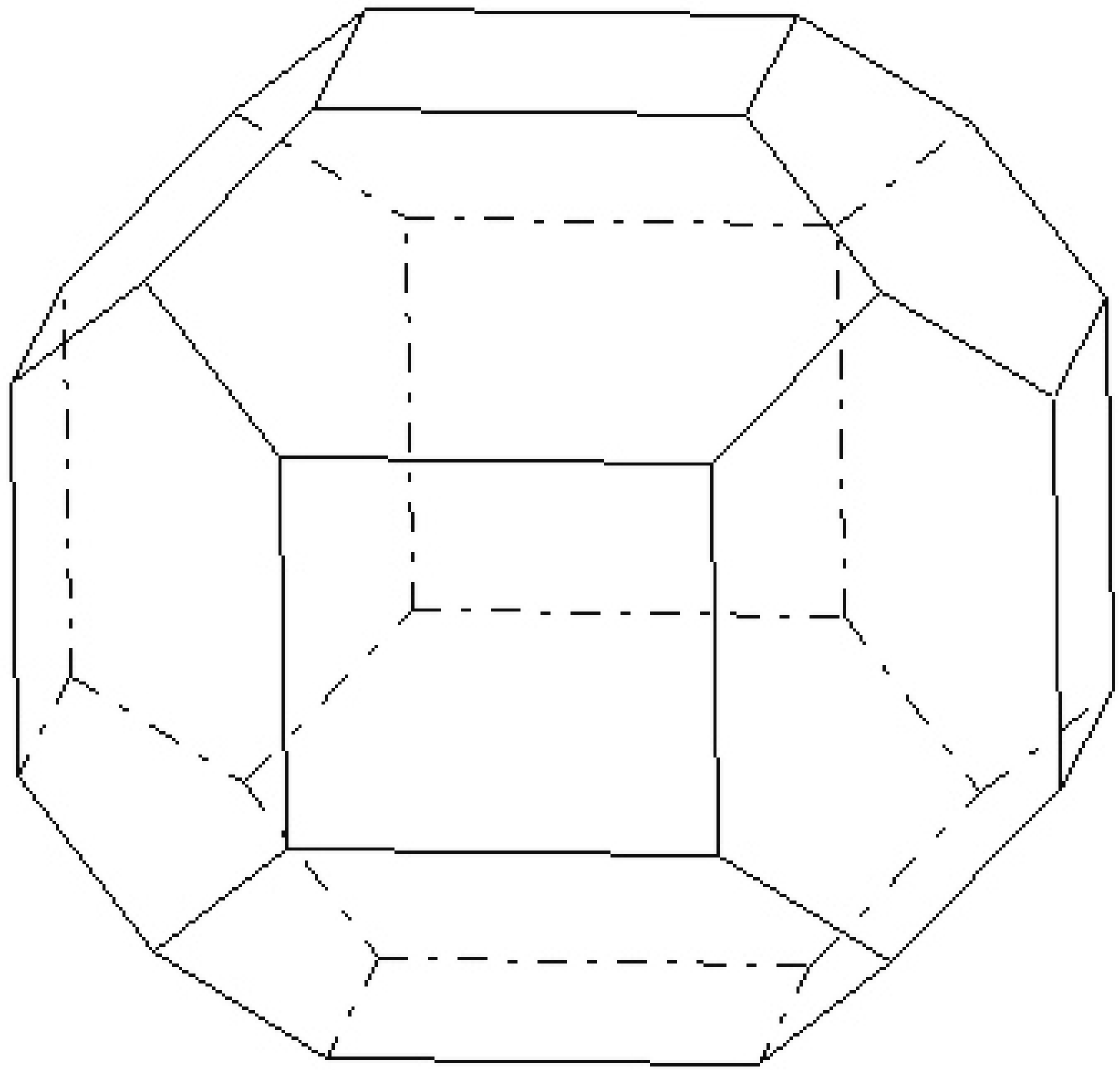


Figure 4 (for the tasks 3 and 4)



Figures 5 (for the task 3 and 5)