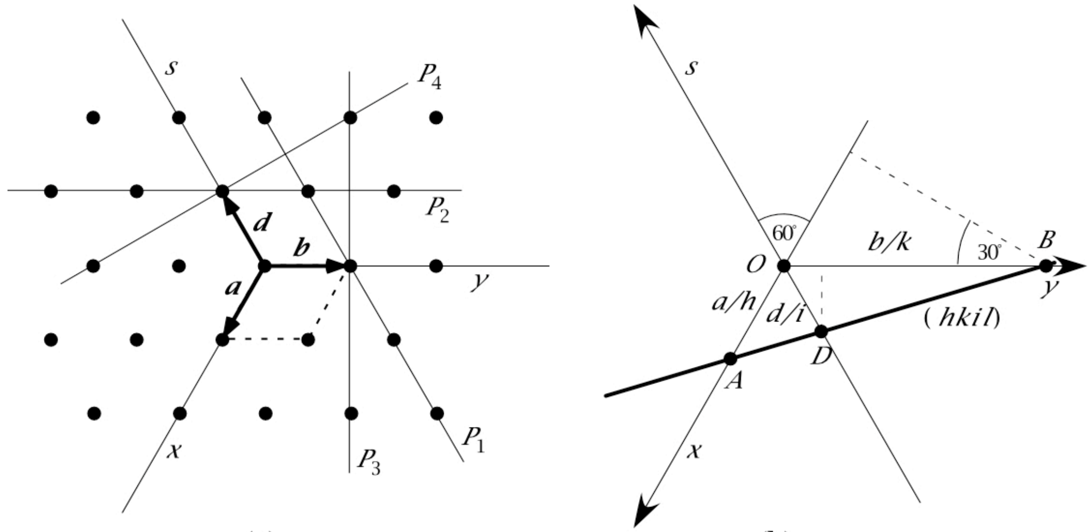
Issued: Sep. 15, Due: Sep. 24.

Problem 1 (20 points)



(a) (b)

(a) Figure (a) shows a hexagonal lattice in [001] projection. Argue why the planes P_1 and P_2 (all planes parallel to the *z*-axis) are symmetrically equivalent to each other. This is also true for P_3 and P_4. Determine the Miller indices (*hkl*) of P_1, P_2, P_3, and P_4.

(b) Although P_1 and P_2 symmetrically equivalent to each other, their Miller indices (hkl) are different. This is the same for the planes P_3 and P_4. For this reason, one introduces a fourth axes, s, and a fourth fundamental translation, ***d***. In this system, lattice planes are described by "Miller-Bravais" indices (*hkil*), where *h* reflects in how many equal parts the planes divide ***a***, *k* reflects in how many equal parts the planes divide ***b***, *i* reflects in how many equal parts the planes divide ***d***, and *l* reflects in how many equal parts the planes divide ***c***.

Determine the *Miller-Bravais* indices (*hkil*) of P_1, P_2, P_3 and P_4. Note that the Miller-Bravais indices reflect that P_1 and P_2 are of the same type and and P_3 and P_4 are of the same type.

(c) Considering Fig. (b), show that for any set (*hkil*) of planes the sum of the first three Miller-Bravais indices vanishes: $h + k + i = 0$

Hint: Equate the area of the triangle OAB to the sum of the areas of OAD and ODB, and express the areas of these triangles with the Miller-Bravais indices.

(d) Lattice directions are expressed by Weber indices [*uvtw*] in the four-axis system. Without an additional condition, however, the notation would be ambiguous (e.g. the *x* direction could be written as [1000] or $[0\bar{1}\bar{1}0]$). Therefore, one requires $u + v + t = 0$. Respecting this condition, (i) express the Weber indices *u*, *v*, *t*, *w* as a function of the conventional (Miller) indices *U*, *V*, *W* (use capital letters for distinction), and (ii) express the conventional indices *U*, *V*, *W* as a function of the Weber indices *u*, *v*, *t*, *w*.

(e) Show that the normal to the plane *(hkil)* will have indices $[defg] = h, k, i, \frac{3a^2}{2c^2} l$.

EMSE314--Fall 2003--Homework 2--Name: ___________________

Issued: Sep. 15, Due: Sep. 24.

Problem 2 (10 points)

Prove that for a crystal with proper rotation C_n, *n* can only be 1, 2, 3, 4 or 6.
Hint: Consider the definition of rotation symmetry. If you start with a row of lattice points, rotate by an angle of $2\pi/n$, you can get another row of lattice points, which must be compatible with the translation symmetry of the crystal.

Problem 3 (10 points)

(a) According to the resistivity versus temperature graph shown in the following figure, determine the temperature coefficient of resistivity of pure iron and of electrotechnical steel (Fe with 4% C), which are used in various electrical machinery, at two temperatures: 0 ^oC and 500 ^oC.
(b) Argue the differences of the resistivity of the two materials and the differences of temperature coefficients of resistivity.

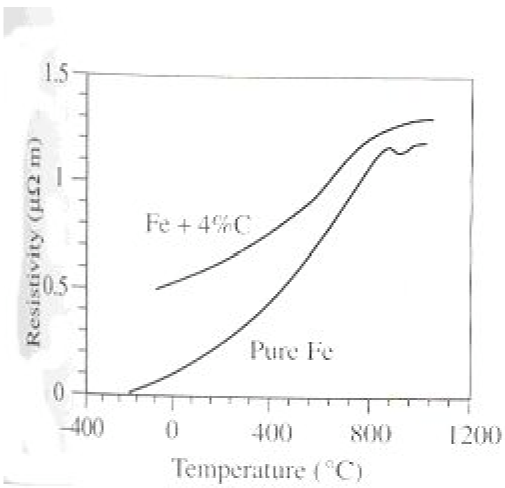


Figure 2.33 Resistivity versus temperature for pure iron and 4% C steel.

Problem 4 (10 points)

(a) As shown in the textbook, the Hall coefficient for electron conduction is given by $R_H = -\frac{1}{en}$. Prove that the Hall coefficient for materials with only positive charge carriers (*e.g.* holes in a semiconductor) is $R_H = \frac{1}{ep}$, where *p* is the carrier concentration.
(b) In the case of an intrinsic semiconductor, such as pure GaAs, the electron and hole concentrations and drift mobilities at 300 K are given as $n = p = 1.8 \times 10^6 cm^{-3}$, $\mu_e \approx 8500 cm^2/Vs$ and $\mu_h \approx 400 cm^2/Vs$. Calculate the Hall coefficient and compare it with that of copper (refer to *Table 2.4* in the textbook).