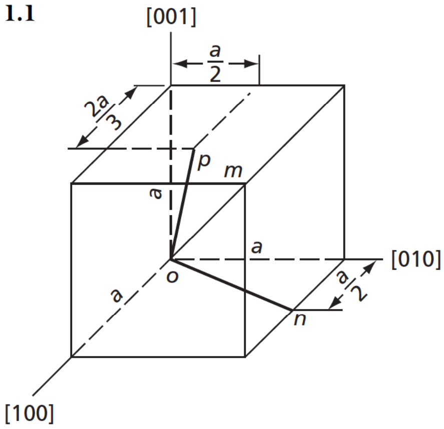
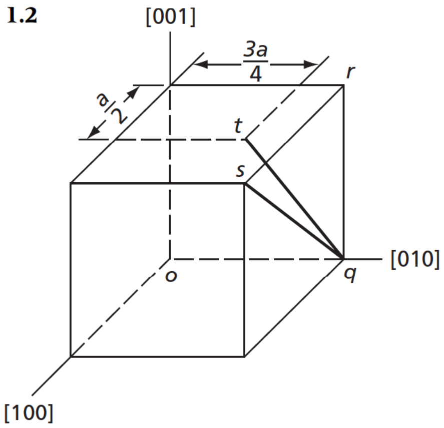
PROBLEMS

1.1



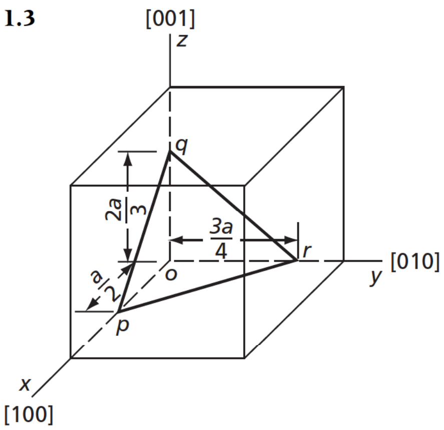
Determine the direction indices for (**a**) line *om*, (**b**) line *on*, and (**c**) line *op* in the accompanying drawing of a cubic unit cell.

1.2



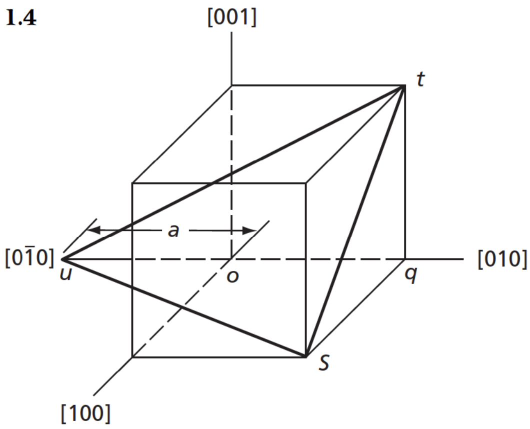
Determine direction indices for lines (**a**) *qr*, (**b**) *qs*, and (**c**) *qt*.

1.3



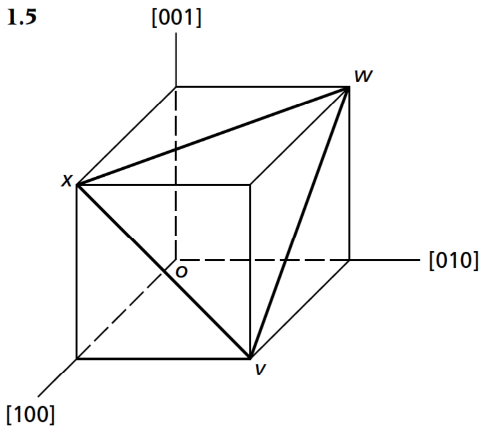
In this figure, plane *pqr* intercepts the *x*, *y*, and *z* axes as indicated. What are the Miller indices of this plane?

1.4



What are the Miller indices of plane *stu*?

1.5



Write the Miller indices for plane *vwx*.

1.6 Linear density in a given crystallographic direction represents the fraction of a line length that is occupied by atoms whereas linear mass density is mass per unit length. Similarly, planar density is the fraction of a crystallographic plane occupied by atoms. The fraction of the volume occupied in a unit cell, on the other hand, is called the atomic packing factor. The latter should not be confused with bulk density, which represents weight per unit volume.

(a) Calculate the linear density in the [100], [110], and [111] directions in body-centered cubic (BCC) and face-centered cubic (FCC) structures.

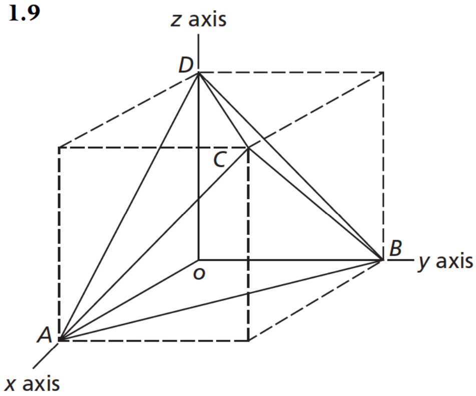
(b) Calculate planar densities in (100) and (110) planes in bcc and fcc structures.

(c) Show that atomic packing factors for BCC, FCC, and hexagonal close-packed (HCP) structures are 0.68, 0.74, and 0.74, respectively.

1.7 Show that the c/a ratio (see Fig. 1.16) in an ideal hexagonal close-packed (HCP) structure is 1.63. (*Hint*: Consider an equilateral tetrahedron of four atoms which touch each other along the edges.)

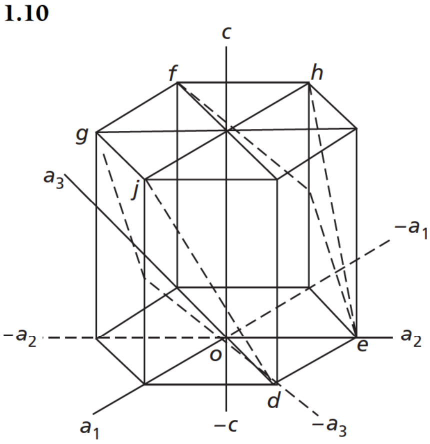
1.8 Iron has a BCC structure at room temperature. When heated, it transforms from BCC to FCC at 1185 K. The atomic radii of iron atoms at this temperature are 0.126 and 0.129 nm for bcc and fcc, respectively. What is the percentage volume change upon transformation from BCC to FCC?

1.9



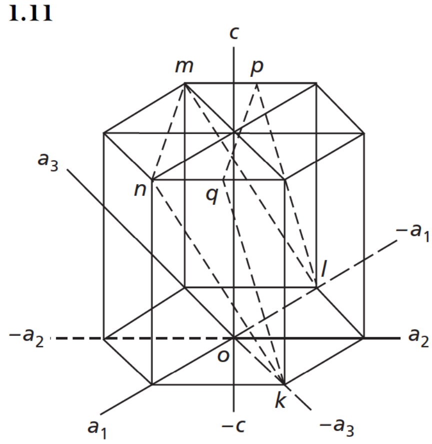
This diagram shows the Thompson Tetrahedron, which is a geometrical figure formed by the four cubic {111} planes. It has special significance with regard to plastic deformation in face-centered cubic metals. The corners of the tetrahedron are marked with the letters *A*, *B*, *C*, and *D*. The four surfaces of the tetrahedron are defined by the triangles *ABC*, *ABD*, *ACD*, and *BCD*. Assume that the cube in the above figure corresponds to a face-centered cubic unit cell and identify, with their proper Miller indices, the four surfaces of the tetrahedron.

1.10



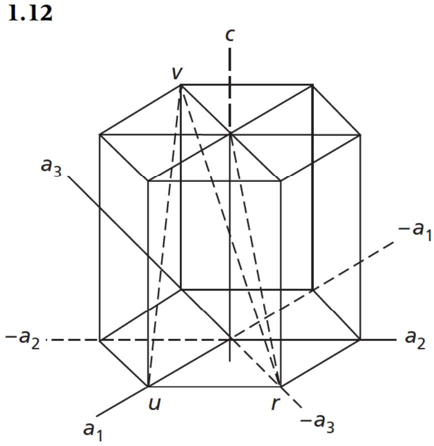
The figure accompanying this problem is normally used to represent the unit cell of a close-packed hexagonal metal. Determine Miller indices for the two planes, *defg* and *dehj*, that are outlined in this drawing.

1.11



Two other hexagonal closed-packed planes, *klmn* and *klpq*, are indicated in this sketch. What are their Miller indices?

1.12



Determine the hexagonal close-packed lattice directions of the lines *rt*, *ut*, and *uv* in the figure for this problem. To do this, first determine the vector projection of a line in the basal plane and then add it to the *c* axis projection of the line. Note that the direction indices of the *c* axis are [0001], and that if [0001] is considered a vector its magnitude will equal the height of the unit cell. A unit distance along a digonal axis of Type I, such as the distance *or*, equals one-third of the length of $[2\bar{1}\bar{1}0]$ in Fig. 1.18. The magnitude of this unit distance is thus equal to $\frac{1}{3}[2\bar{1}\bar{1}0]$. Combine these two quantities to obtain the direction indices of each of the lines.

Stereographic Projection

The following problems involve the plotting of stereographic projections and require the use of the Wulff net, shown in Fig. 1.26, and a sheet of tracing paper. In each case, first place the tracing paper over the Wulff net and then pass a pin through the tracing paper and the center of the net so that the tracing paper may be rotated about the center of the net. Next, trace the outline of the basic circle on the tracing paper and place a small vertical mark at the top of this traced circle to serve as an index.

1.13 Place a piece of tracing paper over the Wulff net as described above, and draw an index mark on the tracing paper over the north pole of the Wulff net. Then draw on the tracing paper the proper symbols that identify the three ⟨100⟩ cube poles, the six ⟨110⟩ poles, and the four ⟨111⟩ octahedral poles as in Fig. 1.33. On the assumption that the basic circle is the (010) plane and that the north pole is [100], mark on tracing paper the correct Miller indices of all of the ⟨100⟩, ⟨110⟩, and ⟨111⟩ poles. Draw in the great circles corresponding to the planes of the plotted poles (see Fig. 1.33). Finally, identify these planes with their Miller Indices.

1.14 Place a piece of tracing paper over the Wulff net and draw on it the index mark at the north pole of the net as well as the basic circle. Mark on this tracing paper all of the poles shown in Fig. 1.30 in order to obtain a 100 standard projection. Now rotate this standard projection about the north–south polar axis by 45° so that the (110) pole moves to the center of the stereographic projection. In this rotation all of the other poles should also be moved through 45° along the small circles of the Wulff net on which they lie. This type of rotation is facilitated by placing a second sheet of tracing paper over the first and by plotting the rotated data on this sheet. This exercise shows one of the basic rotations that can be made with a stereographic projection. The other primary rotation involves a simple rotation of the tracing paper around the pin passing through the centers of both the tracing paper and the Wulff net.

REFERENCES

1. "Metallography and Microstructures," *ASM Handbook*, Volume 9, ASM International, pp. 23–69.

2. K. Honda and S. Kaya, *Sci. Rep*. Tohoku Univ., 15, pp. 721–754 (1926).

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4. "Magnetic Anisotropy of Epitaxial Iron Films on Single-Crystal MgO.001. and Al2O3(112¯0) substrates," Yu. V. Goryunov and I. A. Garifullin, *Journal of Experimental and Theoretical Physics*, 88, 2 (1999), pp. 377–384.