3.60 Symmetry, Structure and Tensor Properties of Materials

Problem Set 17

1. Derive the restrictions imposed upon the diagonal matrix compliances s_{ii} by the presence of a 3-fold rotation axis along [111].

2. Young's modulus, E, is defined as the ratio of tensile stress to tensile strain:

$$E = \frac{\sigma 1}{\varepsilon_1} = \frac{1}{s_{11}}$$

Corundum, α-Al_2O_3 is hexagonal and has point group $\bar{3}$ 2/m. Values of the elastic constants are [J. B. Wachtman, W. E. Test, D. C. Lan and R. P. Stenchfield, J. Nat'l Bur. Stand. 64A [3] 213-228 (1960)] at room temperature:

$S_{11} = 2.353\ (10)^{-13}\ cm^2/dyne$	$C_{11} = 49.68\ (10)^{11}\ dyne/cm^2$
$S_{33} = 2.169$	$C_{33} = 49.81$
$S_{44} = 6.942$	$C_{44} = 14.74$
$S_{12} = -0.716$	$C_{12} = 16.36$
$S_{13} = -0.368$	$C_{13} = 11.09$
$S_{14} = +0.491$	$C_{14} = -2.35$

(a) Derive an expression for Young's modulus for a hexagonal crystal of symmetry $\bar{3}$ 2/m as a function of cosines ℓ_i which specify the orientation of a direction in the crystal.

(b) For Al_2O_3 prepare a polar plot of Young's modulus as a function of direction within the planes:

(i) (001)

(ii) (010)