11.1 We consider the molecule CH₃F discussed in the lecture; the numbering of the nuclei and the character table of the molecular symmetry group $C_{3v}(M)$ are as follows:

The right-handed molecule-fixed axis system $xyz$ for CH₃F is chosen such that the $z$ axis lies along the CF bond, pointing from C towards F, and the $x$ axis lies in the plane defined by the nuclei C, F, and proton H₁, and pointing from the CF axis towards H₁. The following two sketches show how the $xyz$ axis system is affected by the (123) and $(23)^*$ operations, respectively. “($-z$)” indicates that the $z$ axis points into the plane of the paper; “($+z$)” that it points out of the paper plane.
a) Consider a point in space with coordinates \((x, y, z)\) in the molecule-fixed axis system. Determine the coordinates \((x', y', z')\) of this point in the new molecule-fixed axis systems resulting from the application of \((123)\) and \((23)^*\), respectively.

b) Use Cartesian displacement coordinates to determine the representation \(\Gamma_Q\) of \(C_{3v}(M)\) (expressed in terms of the irreducible representations) generated by the normal coordinates \(Q_r\) of \(\text{CH}_3\text{F}\).

c) Determine the representation of \(C_{3v}(M)\) generated by the dipole moment components \((\mu_x, \mu_y, \mu_z)\) along the molecule-fixed axes for \(\text{CH}_3\text{F}\). Determine also the symmetrized linear combinations of \((\mu_x, \mu_y, \mu_z)\).