

1. Translate the following expression from KM notation into our original notation, using daggers to denote creation operators and lines to denote contractions.

$$:a_s^{p^\circ} \bullet_t^{q^\circ} \bullet_{u^\circ}^{r^\circ} : = ?$$

Your final expression should be a Φ -normal-ordered string of six operators with three contraction lines.

2. Expand the following as a linear combination of Φ -normal-ordered operators.

$$\tilde{a}_q^p \tilde{a}_{tu}^{rs} = ?$$

3. Evaluate the following matrix element.¹

$$\langle \Phi_i^a | H - E_{\text{ref}} | \Phi_j^b \rangle = ?$$

¹You may use either of the following equivalent expressions for the Hamiltonian. (I recommend the one on the right!)

$$H = h_p^q a_q^p + \frac{1}{4} \bar{g}_{pq}^{rs} a_{rs}^{pq}$$

$$H = E_{\text{ref}} + f_p^q \tilde{a}_q^p + \frac{1}{4} \bar{g}_{pq}^{rs} \tilde{a}_{rs}^{pq}$$