EXAMPLE formula sheet – may not be *exactly* the same as the final one.

$$\hat{\mathbf{A}}(\mathbf{r},t) = \sum_{\mathbf{k}l} \sqrt{\frac{\hbar}{2\epsilon_0 V \omega_{\mathbf{k}l}}} \boldsymbol{\varepsilon}_{\mathbf{k}l} \left(\hat{a}_{\mathbf{k}l} e^{i(\mathbf{k}\cdot\mathbf{r} - \omega_{\mathbf{k}} t)} + \text{H.c.} \right)$$

$$\mathbf{E} + \boldsymbol{\nabla}\phi = -\partial_t \mathbf{A}$$

$$\mathbf{B} = \boldsymbol{\nabla} \times \mathbf{A}$$

$$\hat{D}(\alpha)^\dagger \hat{a} \hat{D}(\alpha) = \hat{a} + \alpha \hat{1}$$

$$\hat{S}(\xi)^\dagger \hat{a} \hat{S}(\xi) = \cosh(r)\hat{a} - e^{i\varphi}\sinh(r)\hat{a}^\dagger, \quad \xi = re^{i\varphi}$$

$$\hat{B}(T)^\dagger \hat{a} \hat{B}(T) = \sqrt{T}\hat{a} + \sqrt{1-T}\hat{b}$$

$$\hat{S}_2(\xi)\left|0,0\right\rangle = \frac{1}{\cosh r} \sum_{n=0}^{\infty} (-1)^n e^{in\varphi} \tanh^n r \left|n,n\right\rangle$$

$$P_{\langle n\rangle}(n) = \frac{\langle n\rangle^n e^{-\langle n\rangle}}{n!}$$

$$\rho_{\text{thermal}} = \sum_{n=0}^{\infty} \frac{e^{-n\hbar\omega/kT}}{\sum_{m=0}^{\infty} e^{-m\hbar\omega/kT}} \left|n\right\rangle \left\langle n\right|$$

$$W_{\hat{X}}(x,p) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \mathrm{d}x'\, e^{ix'p} \langle x - x'/2 | \hat{X} | x + x'/2 \rangle$$

$$\hat{H}_{\text{total}} = \hat{H}_{\text{atom}} + \hat{H}_{\text{field}} + \hat{H}_{\text{JC}}$$

$$\hat{H}_{\text{atom}} = \frac{\hbar\omega_0}{2} \left(|e\rangle\langle e| - |g\rangle\langle g| \right)$$

$$\hat{H}_{\text{field}} = \hbar\omega \left(\hat{a}^\dagger \hat{a} + \frac{1}{2} \right)$$

$$\hat{H}_{\text{JC}} = \frac{\hbar\Omega_R^{(0)}}{2} \left(|e\rangle\langle g|\, \hat{a} + |g\rangle\langle e|\, \hat{a}^\dagger \right)$$

$$\rho(\omega) = \frac{\omega^2}{\pi^2 c^3}$$

$$\hat{H} = \hat{H}_0 + \hat{H}_I$$

$$\hat{H}_I = \lambda \hat{H}_I'$$

$$\hat{H}_I^{\text{dipole}} = -\hat{\mathbf{D}} \cdot \mathbf{E}(t)$$

$$\gamma_k(t) = \gamma_k^{(0)}(t) + \lambda\gamma_k^{(1)}(t) + \lambda^2\gamma_k^{(2)}(t) + \dots$$

$$i\hbar \frac{\delta\gamma_k^{(r)}(t)}{\delta t} = \sum_n \langle k | \hat{H}_I' | n \rangle e^{i(E_k - E_n)t/\hbar} \gamma_n^{(r-1)}(t)$$

$$R(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

$$[\hat{a}, \hat{a}^\dagger] = \hat{a}\hat{a}^\dagger - \hat{a}^\dagger\hat{a} = \hat{1}$$

$$\hat{a}\left|n\right\rangle = \sqrt{n}\left|n-1\right\rangle$$

$$\hat{a}^\dagger\left|n\right\rangle = \sqrt{n+1}\left|n+1\right\rangle$$

$$\hat{a}\left|\alpha\right\rangle = \alpha\left|\alpha\right\rangle$$

$$\hat{x} = \sqrt{\frac{\hbar}{2m\omega}} \left(\hat{a} + \hat{a}^\dagger \right)$$

$$\hat{p} = -i\sqrt{\frac{\hbar m\omega}{2}} \left(\hat{a} - \hat{a}^\dagger \right)$$

$$[\hat{A}\hat{B}, \hat{C}] = \hat{A}[\hat{B}, \hat{C}] + [\hat{A}, \hat{C}]\hat{B}$$

$$e^{\hat{A}}\hat{B}e^{-\hat{A}} = \hat{B} + [\hat{A}, \hat{B}] + \frac{1}{2!}[\hat{A}, [\hat{A}, \hat{B}]] + \cdots$$

$$e^{\hat{A}+\hat{B}} = e^{\hat{A}} e^{\hat{B}} e^{-[\hat{A},\hat{B}]/2!} e^{[2\hat{B}+\hat{A},[\hat{A},\hat{B}]]/3!} \cdots$$

$$\int_0^\infty \mathrm{d}x \frac{1}{1+x^2} = \frac{\pi}{2}$$

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

$$\sum_{n=0}^{\infty} r^n = \frac{1}{1-r}, \quad |r| < 1$$

$$e^{i\theta} = \cos\theta + i\sin\theta$$

$$\sinh(r) = \frac{e^r - e^{-r}}{2} = -i\sin(ir)$$

$$\cosh(r) = \frac{e^r + e^{-r}}{2} = \cos(ir)$$

$$[\hat{J}_+, \hat{J}_-] = 2\hat{J}_Z$$

$$[\hat{J}_Z, \hat{J}_\pm] = \pm\hat{J}_\pm$$

$$\int_{-\infty}^{\infty} \mathrm{d}x \left|x\right\rangle \left\langle x\right| = \hat{1}$$

$$\int_{-\infty}^{\infty} \mathrm{d}p\, e^{i(x-x')p} = 2\pi\delta(x - x')$$

$$g^{(n)}(X_1, \cdots, X_n; X_{n+1}, \cdots, X_{2n}) = \frac{\langle \hat{E}^{(-)}(X_1) \cdots \hat{E}^{(-)}(X_n) \hat{E}^{(+)}(X_{n+1}) \cdots \hat{E}^{(+)}(X_{2n}) \rangle}{\sqrt{\langle \hat{E}^{(-)}(X_1)\hat{E}^{(+)}(X_1) \rangle \cdots \langle \hat{E}^{(-)}(X_{2n})\hat{E}^{(+)}(X_{2n}) \rangle}}$$