**Potentially Useful Formulae and Constants:**

- **Speed of light**, \( c = 3 \times 10^8 \text{ ms}^{-1} \)
- **Charge of the Electron**, \( e = 1.6 \times 10^{-19} \text{ C} \)
- **Planck’s Constant**, \( h = 6.6 \times 10^{-34} \text{ J s} \)
- **Boltzmann’s constant**, \( k = 1.38 \times 10^{-23} \text{ J K}^{-1} \)
- **Earth-Moon distance**, \( r = 384,000 \text{ km} \)

(The symbols below should be interpreted with their usual meaning)

**Energy of a photon**, \( E = h \nu \)

**Resonator g factors**: \( g_1 = 1 - L/R_1 \), \( g_2 = 1 - L/R_2 \)

**Ray matrices** for a curved mirror, thin lens, propagation, and a spherical dielectric interface:

\[
\begin{bmatrix}
1 & 0 \\
-2/R & 1
\end{bmatrix}
\begin{bmatrix}
1 & 0 \\
-1/f & 1
\end{bmatrix}
\begin{bmatrix}
dI & 0 \\
1/n_2 & n_1/n_2
\end{bmatrix}
\]

**Finesse of a resonator** with no loss apart from that associated with the finite reflectivity of the two mirrors. The mirror reflectivity is expressed in terms of its amplitude reflectivity:

\[
F = \frac{\pi \sqrt{r_1 r_2}}{1 - r_1 r_2}
\]

**Planck’s radiation law**:

\[
u = \frac{8 \pi h \nu^3}{c^3 \left( e^{h \nu/(kT)} - 1 \right)}
\]

**Definition of the complex radius of curvature**:

\[
\frac{1}{q(z)} = \frac{1}{R(z)} - j \frac{\lambda}{\pi w(z)^2}
\]

**Ratio of population densities** in two levels separated by \( \Delta E \) in energy:

\[
n_2/n_1 = e^{-\Delta E/(kT)}
\]

**Q of a cavity resonance mode**: \( Q_c = \nu_0/\Delta \nu \) or \( Q_c = 2\pi \nu_0 \left[ E / (dE/dt) \right] \) or \( Q_c = 2\pi \left[ E/E' \right] \) where \( E \) is the stored energy, \( dE/dt \) is the energy dissipated per second and \( E' \) is the energy dissipated per cycle.

**Gain coefficient** for a 4 level scheme in terms of population differences:

\[
\kappa = \frac{c^2 g(v_r)A}{8\pi \nu_r^2} (n_3 - n_2)
\]

where \( c \) is the speed of light in the material and the rest of the symbols are interpreted as usual.

**Population inversion at threshold for a 4 level laser scheme**:

\[
(n_3 - n_2)/N = W_{41}/(W_{41} + A_{32})
\]