Environmental Engineering — R. Harley
Comprehensive Examination — Dec 2001

AIR POLLUTION MODELING (CEE 218C)

Assuming an atmosphere that has zero turbidity (i.e., no aerosols), estimate the fraction of UV radiation in the direct solar beam that reaches the earth's surface without being absorbed by ozone or scattered by air molecules (Rayleigh scattering). The relevant cross-sections for absorption and scattering at the wavelength of interest (325 nm) are $\sigma_{O3}=1.2\times10^{-20}$ and $\sigma_R=3.5\times10^{-26}$ cm^2 molecule^{-1}, respectively. Atmospheric pressure decreases with height above the earth's surface: $P(z) = P_0 e^{-z/H}$, with H≈8000 m.

Assume the atmosphere is isothermal (T=260 K) and the solar zenith angle is 30 degrees. The column-integrated amount of ozone present overhead is 300 Dobson Units (1 Dobson Unit corresponds to 2.7×10^{16} molecules of ozone per cm^2).

Reference data:

gas constant	R = 8.314 Pa m^3 mol^{-1} K^{-1}
Avogadro's number	$N_A = 6.02\times10^{23}$ molecules per mol
gravitational accel.	g = 9.81 m s^{-2}
sea level pressure	P_0 = 1 atm = 101325 Pa
atomic masses	H=1, C=12, N=14, O=16, Ar=40.
composition of air	21% O_2, 78% N_2, 1% Ar