PHY305A
Exercise Set 5

1. Determine the cross section for scattering of a billiard ball from another billiard ball. Both have a radius equal to $R$.

2. Assume that a galaxy is moving away from us at a speed of 300 Km/s. Determine the observed Doppler shift of a spectral line with frequency $\nu_0 = 5 \times 10^{14}$ Hz produced by this galaxy.

3. Consider an atomic state that has a lifetime of (i) 1 second and (ii) 1 nanosecond. Determine the width, $\Delta E$, of this state. A transition from this state produces a spectral line at visible frequency $\nu_0 = 5 \times 10^{14}$ Hz. Determine the width of this line caused by natural broadening. Compare this with $\nu_0$.

4. Using the surface temperature of the Sun, make a rough estimate of the broadening of Balmer H-alpha line at $\lambda = 6563$ Angstroms.

5. Show that the solution to the differential equation

$$\frac{dI_\lambda}{ds} = -\rho \kappa_\lambda I_\lambda$$

is given by

$$I_\lambda(s) = I_\lambda(0) \exp\left(-\int_0^s \kappa_\lambda \rho ds'\right)$$

6. The visual extinction coefficient $A_V$ for a star at 1 Kpc is approximately 1.8 magnitude. Determine its blue extinction coefficient $A_B$.

7. The absolute magnitude $M_V$ of a star is known to be $-3.0$. Its apparent visual magnitude $V$ is observed to be 12.

   (a) Determine its distance by ignoring $A_V$.

   (b) If we include $A_V$, the distance cannot be computed directly. We can obtain a rough estimate as follows: Compute $A_V$ for $r = 1, 2, 3, 4$ Kpc. Insert these values in the equation

$$V = M_V + 5 \log \frac{r}{10 \text{ pc}} + A_V ,$$

   and compute the distances. The value that is closest to the input distance provides a rough approximation of the true distance. This procedure can now be refined by computing $A_V$ values over intervals of 100 pc and inserting in the above equation. Notice that (a) provides a very poor approximation of the distance.