1. Rayleigh scattering (15 marks)

In lecture we found the total cross section for Rayleigh scattering. What is the differential cross section for unpolarized incoming light?

2. Cherenkov radiation (25=15+10 marks)

An electron moves through water in a tank at a speed v so large that Cherenkov radiation of some frequency is emitted.

(a) Which relation, between the electron's velocity vector $\vec{v}$ and the normal vector $\vec{e}_z$ of the surface, must be obeyed so that the Cherenkov radiation can be observed above the water?

(b) Can one observe the Cherenkov radiation from an electron that moves parallel to the surface?

3. Antenna array (30=20+10 marks)

An odd number $N = 2M + 1$ of identical ring antennas are placed along the z-axis, so that their centres are at $z = 0, \pm D, \pm 2D, \ldots, \pm MD$ and each antenna ring is parallel to the x, y-plane. All antennas have the same radius a and carry the same periodic current $I\cos(\omega t)$.

(a) Use the known answer for a single ring antenna to find $\dfrac{\mathrm{d}P}{\mathrm{d}\Omega}$, the angular distribution of the radiated power, averaged over one period, for this array of N antennas.

(b) How does the many-antenna radiation pattern differ from the single-antenna pattern?

4. Bremsstrahlung (30=20+10 marks)

Charge e is moving with constant velocity $\vec{v}_0$ until it is stopped by a constant acceleration that lasts for duration T.

(a) Apply the relativistic version of Larmor's energy-loss formula to find the total radiated energy E_{rad}.

(b) Which simplified expression applies when $v_0 \lesssim c$?