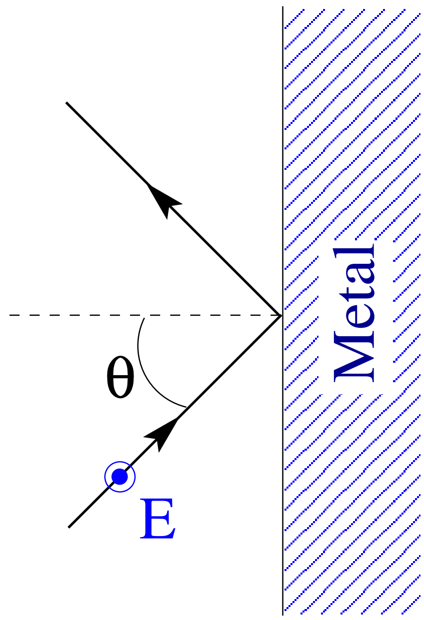
1. A perfectly insulating rigid sphere of radius R with charge density $\rho(r)$ is rotating with angular frequency ω about the z axis.

   (a) What is the electrostatic potential $\Phi(r)$ for all r? Assume that $\phi(\infty) = 0$.

   (b) What is the current density vector $\mathbf{J}(\mathbf{r})$ inside the sphere?

   (c) What is the magnetic field $\mathbf{B}(\mathbf{r})$ for all positions $\mathbf{r}$.

   (d) Evaluate $\mathbf{B}(0)$. It should be expressible in terms of ω, fundamental constants and $\Phi(0)$.



2. A monochromatic plane wave of frequency ω and wave vector k is incident onto the flat metal-air interface from the air side. The incident angle is θ. The electric field of the incident beam is perpendicular to the plane of incidence. The maximum amplitude of the electric field is E. The metal's permitivity, permeability, and conductivity are ϵ, μ, and σ.

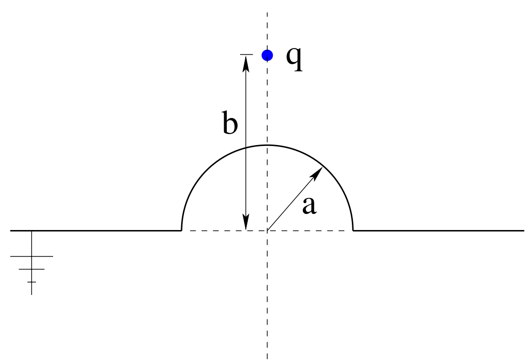
   (a) First calculate the reflected and transmitted electric field in the case where $1/\omega$ is very long compared to other time scales in the system.

   (b) Find the approximate value of ω where the behavior of the system undergoes a qualitative change and describe that change.

3. A particle of charge e and mass m moves in a circle of radius a in a uniform magnetic field B.

   (a) Assuming $v \ll c$, derive the angular distribution of the far-field radiation intensity $dI/d\Omega$ at one particular time t.

   (b) Find the angular distribution of the radiation intensity $dI/d\Omega$ averaged over one cycle.



4. A conducting plane, which is grounded, has a hemisphere-shaped bump. The center of the sphere is on the plane, and its radius is a. A point charge q is placed at the symmetry axis of the system. Its distance to the plane is b ($b > a$).

   (a) Use the charge imaging method to find the electrostatic potential distribution.

   (b) Find the induced charge on the hemispherical bump.