M07E.2 - Noise in a Circular Ring

Problem

A circular ring of radius a is made from copper wire. The ring is held at a temperature T. The wire diameter is d and its electrical conductivity is σ.

a) What is the voltage noise across the ends of the wire if the ring is open? State your result in terms of root mean square voltage V_n in a frequency bandwidth Δf. Use V_n in subsequent parts if you are uncertain about its value.

b) Suppose the ends of the ring are shorted. What is the r.m.s. magnetic field noise in a bandwidth Δf at the center of the ring at very low frequencies?

c) Consider the r.m.s. magnetic noise in a narrow bandwidth Δf around a central frequency f. The magnetic field noise is constant up to some critical frequency f_c and drops as f^{-p} for frequencies much higher than f_c. There are two effects which are responsible for this decrease of the magnetic noise in the radio-frequency range, where the electrical conductivity σ is nearly constant. What are these effects? Give a rough estimate of f_c, which is approximately the same for both effects, and find the power p.