Electromagnetic Waves, Energy, and Power

Preliminaries

```
In[•]:= ϵ0 = Quantity[1, "ElectricConstant"];
        c = Quantity[1, "SpeedOfLight"];
        μ0 = Quantity[1, "MagneticConstant"];
```

```
In[•]:= Savg[e_] := 1/2 ϵ0 c e^2
```

99.9 - The Hawk

The radio station broadcasts at 99.9 MHz with a power of 50,000 Watts. What is the wavelength of the radio waves? What are the maximum electric and magnetic fields at a distance of 1.25 kilometers from the station? (Assume the power radiates evenly in all directions.)

```
In[•]:= f = Quantity[99.9, "MegaHertz"];
```

```
In[•]:= λ = c / f; UnitConvert[λ, "Meters"]
Out[•]= 3.00093 m
```

Use the 1/r^2 law to find the intensity.

```
In[•]:= P = Quantity[50 000, "Watts"];
        r = Quantity[1.25, "Kilometers"];
```

```
In[•]:= Intens = P/(4 π r^2); UnitConvert[Intens, "Watts/Meter^2"]
Out[•]= 0.00254648 W/m^2
```

```
In[•]:= Clear[e]
        e = e /. Solve[Savg[e] == Intens && e > 0, e][[1]]
Out[•]= 1.38516 V/m
```

```
In[•]:= B = e / c ; UnitConvert[B, "Teslas"]
Out[•]= 4.6204 × 10^-9 T
```

Laser Pointer

A 0.24 mW red laser pointer (λ = 655 nm) is focused onto a spot 3 cm^2 a distance 5.0 m away. What is the frequency of the light wave? What is the intensity of the laser? What are the maximum values of the electric and magnetic field in the spot?

```
In[•]:= λ = Quantity[655., "Nanometers"];
        f = c / λ; UnitConvert[f, "Hertz"]
```

Out[•]= 4.57698×10^{14} Hz

```
In[•]:= A = Quantity[3.0, "Centimeters^2"]
```

Out[•]= 3. cm^2

```
In[•]:= P = Quantity[0.24, "Milliwatts"];
```

```
In[•]:= Intens = P / A; UnitConvert[Intens, "Watts/Meter^2"]
```

Out[•]= 0.8 W/m^2

```
In[•]:= Clear[e]; e = e /. Solve[Savg[e] == Intens && e > 0, e][[1]]
```

Out[•]= 24.5513 V/m

```
In[•]:= B = e / c ; UnitConvert[B, "Teslas"]
```

Out[•]= 8.18945×10^{-8} T