Solution to the practice problems in the Interference notes:

1. Because soap has higher index of refraction than air, the first reflected ray has a phase shift of 180^{o} and the second reflected ray has no phase shift, so you want to have the $\frac{1}{2}\lambda$ in your path difference to have constructive interference.

<u>Maximum reflection</u>: constructive interference

$$2dn = \left(m + \frac{1}{2}\right)\lambda$$

$$2(0.5\mu m)(1.33) = \frac{1}{2}\lambda$$

(Set m=0 because you are looking for the *longest* wavelength. Soap has the same refractive index as water.)

So $\boldsymbol{\lambda = 2.66\ \mu m}$

Minimum reflection: destructive interference

$$2dn = m\lambda$$

$$2(0.5\mu m)(1.33) = \lambda \qquad (m = 1)$$

So $\boldsymbol{\lambda = 1.33\ \mu m}$

2. You want to get rid of the background haze, so you're looking for *destructive* interference. The first reflected ray (at the air-coating interface) has a phase shift because $n_{coating} > n_{air}$. The second reflected ray (at the coating-glass interface) also has a phase shift because $n_{glass} > n_{coating}$. So the two reflected rays don't have any phase difference relative to each other, and you don't need to have the $\frac{\lambda}{2}$ in your path difference for constructive interference.

Destructive interference:

$$2dn_{coating} = \left(m + \frac{1}{2}\right)\lambda$$

$$d = \left(m + \frac{1}{2}\right)\lambda\left(\frac{1}{2n_{coating}}\right)$$

$$d = \frac{1}{2}(350nm)\left(\frac{1}{2(1.3)}\right)$$

$$\boldsymbol{d = 67.3\ nm}$$

3.

(a) Intensity:

$$I_{avg} = \frac{P_{avg}}{A} = \frac{800W}{4\pi D^2}$$

(b) Intensity is also

$$I_{avg} = \frac{1}{\mu_0} E_{avg} B_{avg} = \frac{\epsilon_0 c}{2} (E_{max})^2$$

So

$$E_{max} = \sqrt{\frac{2}{\epsilon_0 c}\frac{P_{avg}}{4\pi D}} = \sqrt{\frac{2}{8.8 * 10^{-12} * 3 * 10^8}\frac{800W}{4\pi(3.5)^2}} = \boldsymbol{62.75\ (V/m)}$$

$$B_{max} = \frac{E_{max}}{c} = \mathbf{2.09 * 10^{-7}}\ (\boldsymbol{T})$$

4. We have: $s_1 = 15cm$

Find the location of the image of the first lens:

$$\frac{1}{f_1} = \frac{1}{s_1} + \frac{1}{s_1'}$$

$$\frac{1}{s_1'} = \frac{1}{f_1} - \frac{1}{s_1} = \frac{1}{30} - \frac{1}{15} = -\frac{1}{30}$$

So the image of the first lens is 30cm to the left of the first lens, upright and virtual. It's also the object of the second lens, hence:

$$s_2 = s_1' + 20\ cm = 30 + 20\ (cm) = 50\ cm$$

Find the location of the image of the second lens:

$$\frac{1}{s_2'} = \frac{1}{f_2} - \frac{1}{s_2} = -\frac{1}{10} - \frac{1}{50} = -\frac{3}{25}$$

$$s_2' = -8.3cm$$

So the final image is 8.3 cm left of the second lens, also upright and virtual.

Magnification of the final image:

$$M = M_1 M_2 = \left(-\frac{s_1'}{s_1}\right)\left(-\frac{s_2'}{s_2}\right) = \left(\frac{30}{15}\right)\left(\frac{\frac{25}{3}}{50}\right) = \mathbf{\frac{1}{3}}$$