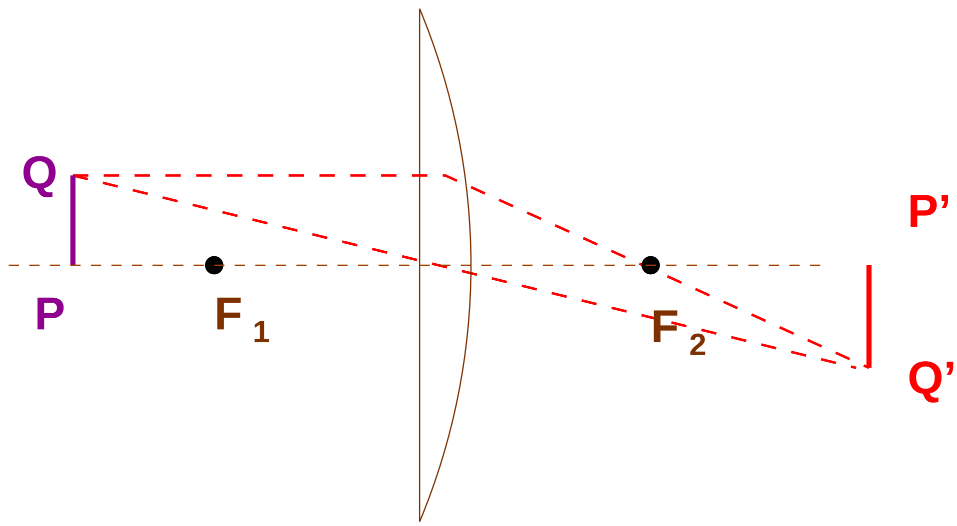
PHYSICS 232 - Solution Key to Sample Test 2

1a. Sound propagates through vibrations of molecules. Light consists of electromagnetic fields. There are no molecules in outer space, so sound cannot propagate, but light can, because electromagnetic fields exist in vacuum.

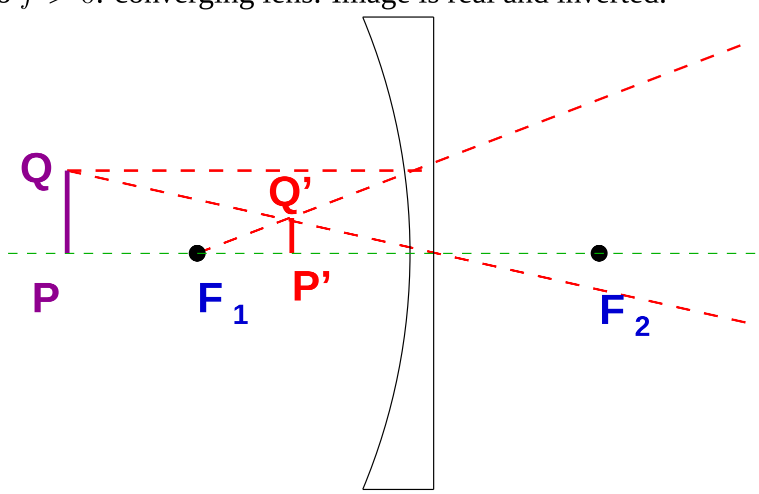
1b. Yes. They are both made of electromagnetic fields. They have different frequencies (light has higher frequency than radio waves).

1c. Use

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



$R_1 = \infty$, $R_2 < 0$, so $f > 0$: converging lens. Image is real and inverted.



$R_1 < 0$, $R_2 = \infty$, so $f < 0$: diverging lens. Image is virtual and erect.

1d. Use

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

In the eye, s' does not change. So if you increase s, you increase f.

2a. Pressure = F / A = I / c, and I = Power / A, so

$$F = \frac{IA}{c} = \frac{Power}{c} = \frac{100}{3 \times 10^8} = 3.3 \times 10^{-7}\ N$$

2b. The acceleration is

$$a = \frac{F}{M} = \frac{3.3 \times 10^{-7}}{250} = 1.33 \times 10^{-9} m/s^2$$

2c. We have $d = \frac{1}{2}at^2$, where d = 6 m. Therefore,

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2 \times 6}{1.33 \times 10^{-9}}} = 9.5 \times 10^4 s = 26\ hrs$$

3a. In vacuum,

$$\lambda_0 = \frac{c}{f} = \frac{3 \times 10^8}{5 \times 10^{14}} = 6 \times 10^{-7} m$$

In the glass plate,

$$\lambda = \frac{\lambda_0}{n} = \frac{6 \times 10^{-7}}{1.5} = 4 \times 10^{-7} m$$

3b. In the glass plate, the speed of light is

$$v = \frac{c}{n} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 m/s$$

So,

$$t = \frac{d}{c} = \frac{3 \times 10^{-3}}{2 \times 10^8} = 1.5 \times 10^{-11} s$$

4. Using

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

we obtain

$$s' = \frac{fs}{s - f}$$

We have f = R/2 = 1 m and s = 380,000 km. Since s is much larger than f, we obtain $s' = f$ (image at focal point).

The magnification is

$$m = \frac{y'}{y} = -\frac{s'}{s} = -\frac{f}{s}$$

where y = 3,420 km. Therefore, the size of the image is

$$|y'| = y\frac{f}{s} = 3,420 \times 10^3 \frac{1}{380,000 \times 10^3} = 0.009\ m = 9\ mm$$

5. In air, the wavelength is $\lambda_0 = 500$ nm. In the coating, $\lambda = \frac{\lambda_0}{n} = \frac{500}{1.42} = 352$ nm.
Since glass has a larger index of refraction, for destructive interference, $2t = m\lambda$.
Minimum thickness: $t = \frac{\lambda}{2} = \frac{352}{2} = 176$ nm.