(16 pts) 1. A thin horizontal film of water with thickness $7.00 \times 10^{-8}$ m and refractive index $n = 1.33$ has air above and below it. The film is illuminated by a beam of white light that is normal to the film. What is the largest wavelength of the light in air for which there is constructive interference between the light reflected from the upper and lower surfaces of the film?

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\text{Ans. } 372 \text{ nm}
\]
(15 pts) 2. Coherent laser light passes through a narrow slit that has width $1.50 \times 10^{-4}$ m and falls on a screen that is 4.00 m from the slit. In the diffraction pattern on the screen the width of the central maximum is $3.00 \times 10^{-2}$ m. What is the wavelength of the light?

**Ans.** $563 \text{ nm}$

(15 pts) 3. A ray of light traveling in glass is incident on the interface between the flat surface of the glass and a liquid. The refractive index of the glass is 1.70. If the incident ray makes an angle smaller than $38.0^\circ$ with the surface of the glass, no light refracts into the liquid. What is the speed of light in the liquid?

**Ans.** $2.24 \times 10^8 \text{ m/s}$
(16 pts) 4. A plane sinusoidal electromagnetic wave in air has a magnetic field amplitude of $B_{\text{max}} = 8.00 \times 10^{-7}$ T. What average force does this radiation exert perpendicular to its direction of propagation on a totally reflecting surface with area $0.300 \text{ m}^2$?

Ans. $1.53 \times 10^{-7} \text{ N}$
(18 pts) 5. An upright object that is 2.0 mm tall is placed to the left of a concave spherical mirror that has focal length \( f = +20.0 \) cm. The image is 4.0 mm tall and is upright.

a) Is the image real or virtual?
Ans. Virtual

b) Is the image to the left or to the right of the mirror?
Ans. To the right

c) How far is the object from the mirror vertex?
Ans. 10.0 cm
(20 pts) 6. A converging lens with focal length $f_1 = +20.0 \text{ cm}$ is $25.0 \text{ cm}$ to the left of a diverging lens that has focal length $f_2 = -15.0 \text{ cm}$. An object that is $2.0 \text{ mm}$ tall is placed $8.00 \text{ cm}$ to the left of the converging lens.

a) What is the object distance for the second lens?

Ans. $38.3 \text{ cm}$

b) Is the final image real or virtual?

Ans. virtual

c) Is the final image upright or inverted?

Ans. upright

d) How far is the final image from the diverging lens?

Ans. $10.8 \text{ cm to the left}$