1. \[ \lambda_{\text{wave}} = \frac{\lambda}{n} \Rightarrow \lambda_{\text{wave}} = \frac{1}{1.33} = 0.75 \text{ m} \]

9. This asks for the first minimum.

\[ \sin \theta = \left( \frac{m+\frac{1}{2}}{n} \right) \lambda \]

So,

\[ d = \frac{\lambda}{2 \sin \theta} = \frac{410 \times 10^{-9} \text{ m}}{2 \sin 45^\circ} = 290 \times 10^{-7} \text{ m} = 290 \mu\text{m} \]

(If you misread it, you might have used \( \sin \theta = m \lambda \) but this is for maximum (bright spots).)

15. Maximum, \( m = 2 \)

\[ \lambda = 720 \times 10^{-9} \text{ m} \]

\[ d \sin \theta = 2 \lambda \]

\[ d = \frac{2 \lambda}{\sin \theta} \]

The limit of \( \sin \theta \) is 1 when \( \theta = 90^\circ \).

So,

\[ d = \frac{2 \times 720 \times 10^{-9} \text{ m}}{1} = 1.44 \times 10^{-6} \text{ m} = 1.44 \mu\text{m} \]

27. \[ \frac{10,000 \text{ lines}}{\text{cm}} \quad d = \frac{1}{\text{cm}} = \frac{0.1 \text{ m}}{10,000 \text{ lines}} = \frac{1.0 \times 10^{-6} \text{ m}}{1 \text{ line}} \]

\[ d \sin \theta = \sqrt[2]{\lambda} \quad \text{so} \quad \lambda = d \sin \theta = \frac{1.0 \times 10^{-6} \text{ m}}{\sin 36.093^\circ} = 589.1 \text{ nm} \]

And \( \lambda = d \sin \theta = \frac{1 \times 10^{-6} \text{ m}}{\sin 36.129^\circ} = 589.6 \text{ nm} \)
31. \[ \Delta \theta = m \lambda \\
We want to show that \( \theta \) can exist under certain conditions. \( \theta < 90^\circ \) (otherwise it's going the wrong way!), so \( \sin \theta < 1 \).
\[ \sin \theta = \frac{m \lambda}{d} < 1 \]

If \( m = 2 \), then \( \frac{2 \lambda}{d} < 1 \), so \( \frac{\lambda}{d} < \frac{1}{2} \).

OK. Now set up this condition for the \( m = 1 \) case, and see what \( \theta \) is:
\[ \Delta \theta = \frac{1}{m} \lambda \\
\sin \theta = \frac{\lambda}{d} < \frac{1}{2} \quad \text{so} \quad \sin \theta < \frac{1}{2} \]
\[ \theta < 30.0^\circ \]

39. \( D = 2.00 \times 10^{-6} \) m, \( m = 1 \)

a. \( \lambda = 410 \times 10^{-9} \) m
\[ \Delta \sin \theta = m \lambda \]
\[ \sin \theta = \frac{\lambda}{D} = \frac{410 \times 10^{-9} \text{m}}{2 \times 10^{-6} \text{m}} \implies \theta = 11.8^\circ \]

b. \( \lambda = 700 \) \( \mu \)m

As above, \[ \sin \theta = \frac{\lambda}{D} = \frac{700 \times 10^{-9} \text{m}}{2 \times 10^{-6} \text{m}} \implies \theta = 20.5^\circ \]

44. \( \lambda = 589 \times 10^{-9} \) m
\( D = 7.50 \times 10^{-6} \) m, \( m = 2 \)

a. \( \Delta \sin \theta = m \lambda \)
\[ \sin \theta = \frac{m \lambda}{D} = 0.157 \]
\[ \theta = 9.04^\circ \]

b. For what \( m \) is \( \sin \theta < 1? \) \( (\theta < 90^\circ) \)
\[ \frac{\lambda}{D} \leq \sin \theta = \frac{1}{m} \lambda \]
\[ m \geq \frac{D}{\lambda} = \frac{7.50 \times 10^{-6} \text{m}}{589 \times 10^{-9} \text{m}} = 12.7 \text{ so } m \geq 12 \]
56. $D = 5.08 \text{ m}$

$\theta = 1.22 \frac{\lambda}{D} = 1.22 \frac{550 \times 10^{-9} \text{ m}}{5.08 \text{ m}}$

$\bar{\lambda} = 550 \times 10^{-9} \text{ m}$

$\theta = 1.32 \times 10^{-4} \text{ radians}$

The angle between Pluto & Charon:

The best resolution of this cheap-o telescope

$\theta = \frac{S}{r} = \frac{1.96 \times 10^4 \text{ km}}{4.5 \times 10^9 \text{ km}} = 4.36 \times 10^{-6} \text{ radians}$

Since the angle we need to resolve is greater than the minimum angle of the scope, this separation is possible. (You'd need to get rid of the air above the scope to help, though.)

60. $\lambda = 470 \text{ nm}$

Phase shift!

With one phase shift:

$2t = \frac{\lambda}{2} = \frac{\lambda}{2\pi}$

$\left(\text{Air } n = 1.00\right)$

$\left(\text{Oil } n = 1.40\right)$

$\left(\text{Water } n = 1.33\right)$

for constructive, need $\Delta \theta = \pi n$, but phase shift gives you an extra $\frac{\pi n}{2}$, so only

$t = \frac{\lambda}{4\pi}$

$t = \frac{470 \text{ nm}}{4(1.40)} = 83.9 \text{ nm}$

$= 8.39 \times 10^{-8} \text{ m}$
This is a poorly worded question. What it's supposed to be saying is:
\[ t = \frac{7\pi}{4} = \frac{\lambda}{4n} \quad \text{for all visible } \lambda \text{'s.} \]

The text assumes \( \lambda = 760 \text{ nm} \) is the greatest possible value. Then:
\[ t = \frac{760 \text{ nm}}{4(1.33)} = 143 \text{ nm} \]

This is smaller than \( \lambda \)'s of visible light — no wonder the bubble usually pops before this condition.

71. \( I = I_0 \cos^2 \theta \)

If \( \frac{I}{I_0} = \frac{1}{2} \), then \( \cos^2 \theta = \frac{1}{2} \)
\[ \cos \theta = \sqrt{\frac{1}{2}} \]
\[ \theta = 45.0^\circ \]

Oh, of course...
7a. Angle between the first two: \( \Theta = 45.0^\circ \)

\[
\frac{I_1}{I_0} = \cos^2 45^\circ = \frac{1}{2} = 0.500
\]

Between 2\textsuperscript{nd} and 3\textsuperscript{rd}, \( \Theta = 45.0^\circ \)

\[
\frac{I_2}{I_0} = \cos^2 45^\circ = \frac{1}{2} = 0.500
\]

\[
\frac{I_2}{I_0} = \frac{I_2}{I_0} \quad \frac{I_1}{I_0} = (0.50)(0.50) = 0.250
\]

83a. \( \Theta = 62.5^\circ \quad \tan \Theta = \frac{n_2}{n_1} = \frac{n_2}{1.00} \)

\[
\tan 62.5^\circ = \frac{n_2}{1.00} \Rightarrow n_2 = 1.92
\]

\( n_2 = 1.92 \quad n_1 = 1.33 \)

\[
\tan \Theta = \frac{n_2}{n_1} = \frac{1.92}{1.33} \Rightarrow \Theta = 55.3^\circ
\]

(\( n_{\text{diamond}} = 2.4 \), so this is not a diamond)