SOUND: \( v_{\text{wave}} = \sqrt{\frac{B}{\rho}} \) BULK MODULUS

\[ B = \frac{-\Delta P}{(\Delta V/V_0)} \text{ HOW MUCH SOMETHING RESISTS PRESSURE} \]

\[ \text{[N/m}^2\text{]} \]

\[ \text{Pa} \]

Q: SPEED OF SOUND FASTER IN AIR OR WATER?

\( \rho_{\text{air}} = 1.21 \text{ Kg/m}^3 \)

\( \rho_{\text{water}} = 1000 \text{ Kg/m}^3 \)

\( B_{\text{air}} = 1.4 \times 10^5 \text{ N/m}^2 \)

\( B_{\text{water}} = 2.2 \times 10^9 \text{ N/m}^2 \)

\( v_{\text{air}} = 343 \text{ m/s} \)

\( v_{\text{water}} = \sim 1,500 \text{ m/s} \)

Close call, can't tell from just \( \rho \) or \( B \) alone.
LIGHT

See lecture #11 for detailed drawings

SNELL'S LAW OF REFRACTION

\[ n_a \sin \theta_a = n_b \sin \theta_b \]

LAW OF REFLECTION

\[ \theta = \theta' \]

CHROMATIC DISPERSION

\textbf{SMALLER } \lambda \textbf{ } \rightarrow \textbf{LARGER } n

\textbf{\rightarrow PRISMS}

\textbf{\rightarrow RAINBOWS AS AN EXAMPLE}

(www.sundog.clara.co.uk/rainbows/bow.htm)

TOTAL INTERNAL REFLECTION

Low \( n_a \)

\[ \theta_1 = 90^\circ \]

HIGH \( n_b \)

SNELL'S LAW

\[ \theta_{\text{critical}} = \sin^{-1}\left(\frac{n_a}{n_b}\right) \]
THIN LENS EQUATION

\[
\frac{1}{F} = \frac{1}{S} + \frac{1}{S'}
\]

be careful with signs

\(F\) positive for convex \(\bigcirc\)
\(F\) negative for concave \(\blacksquare\)

\(S'\) positive for real image
\(S'\) negative for virtual image

PRINCIPAL RAYS: should be able to draw image position on a lens diagram using these.

See first 2 pages of LECTURE #12 for detailed drawings in old notes.