LECTURE 6 PHYSICS 301

THESE NOTES ALREADY APPEARED IN PREVIOUS LECTURES — THE TOPICS WERE NOT COVERED

TOPICS —

DOPPLER EFFECT . SHOCK WAVES
THE WAVE EQUATION FOR WAVES ON A STRING —
PARALLELS OF THIS EQUATION WITH PLANETARY MOTION & MOTION OF AN ELECTRON AROUND A PROTON. —
WAVE LENGTH ON A STRING →
SPECTRUM OF HYDROGEN
EXAMPLES OF SIMPLE HARMONIC MOTION

Doppler EFFECT

WHAT HAPPENS TO FREQUENCY & WAVELENGTH WHEN SOURCE IS MOVING, WHEN OBSERVER IS MOVING - BOTH MOVING

STATIONARY CASE

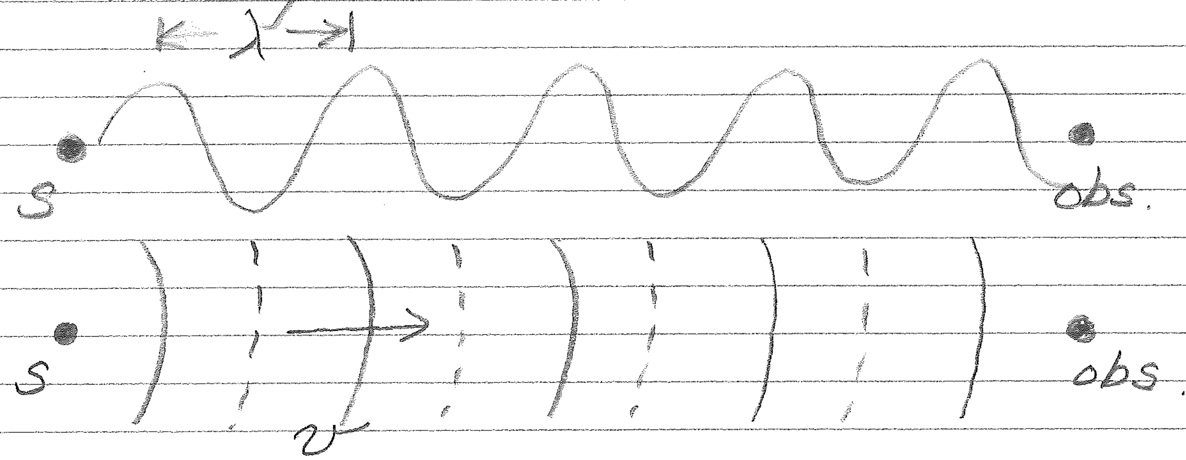
A STATIONARY SOURCE EMITS A HARMONIC WAVE VIBRATING AT FREQUENCY f WITH PERIOD T. THE WAVE PROPAGATES WITH SPEED v. IN ONE PERIOD T THE WAVEFRONT HAS ADVANCED λ:

$$vT = D \qquad T = \frac{1}{f} \qquad v\frac{1}{f} = D \qquad v = Df$$

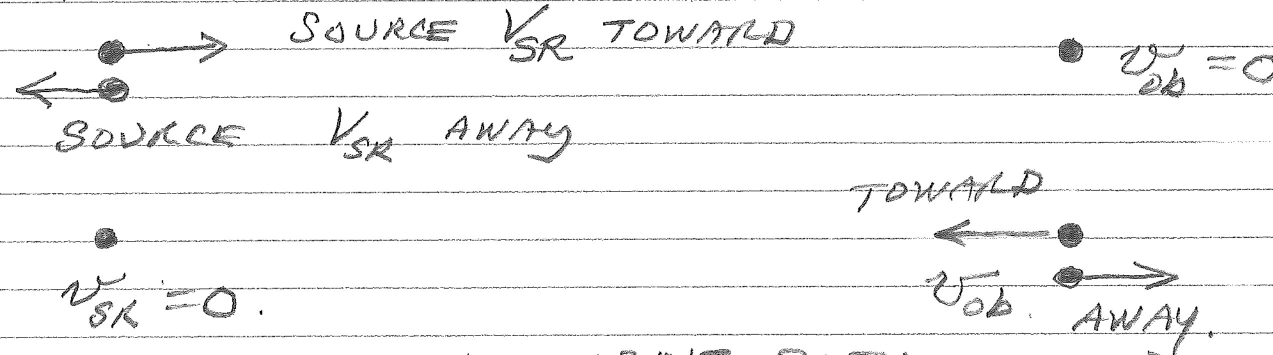
BUT $v = \lambda f \qquad D = \lambda$ ✓

PERCEPTION OF f CAN BE ALTERED IS SOURCE MOVES OR OBSERVER MOVES

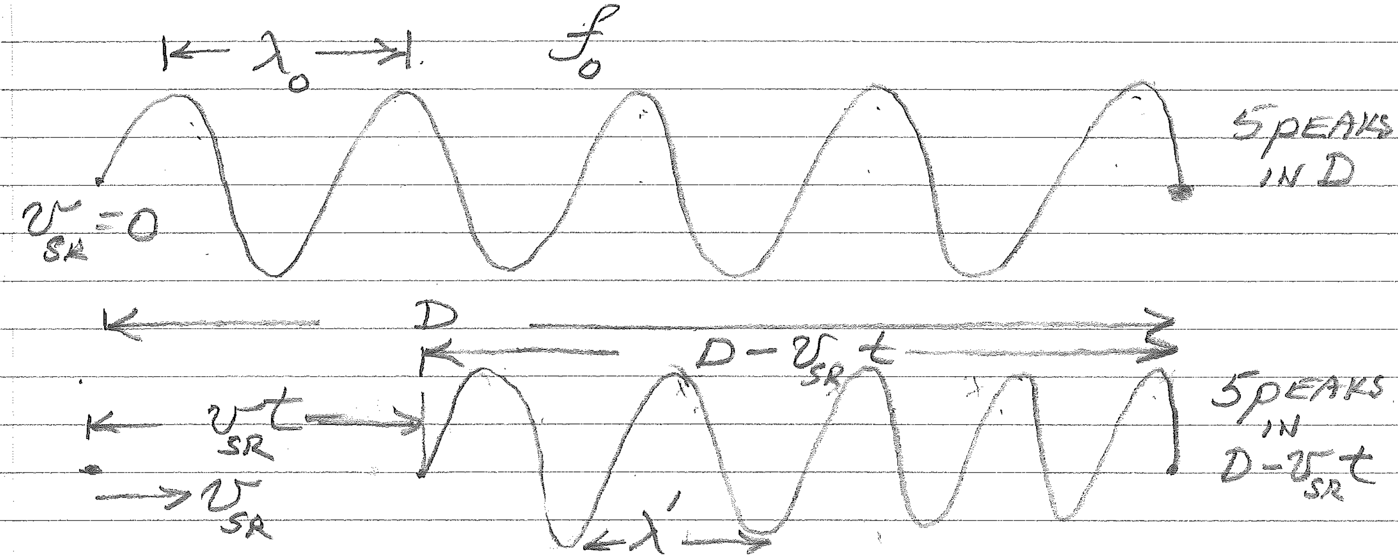
STATIONARY CASE



CASES.



CAN COMBINE BOTH



t = TIME IT TAKE FOR SOUND TO GO FROM SOURCE TO OBSERVER $= D/v$

λ IS REDUCE f IS INCREASED

$$D' \equiv D - v_{SR} t = D - D\frac{v_{SR}}{v} = D\left(1 - \frac{v_{SR}}{v}\right)$$

$$\frac{\lambda'}{\lambda_0} = \frac{D\left(1 - \frac{v_{SR}}{v}\right)}{D} = 1 - \frac{v_{SR}}{v} \qquad \lambda' \downarrow \text{SHORTER}$$

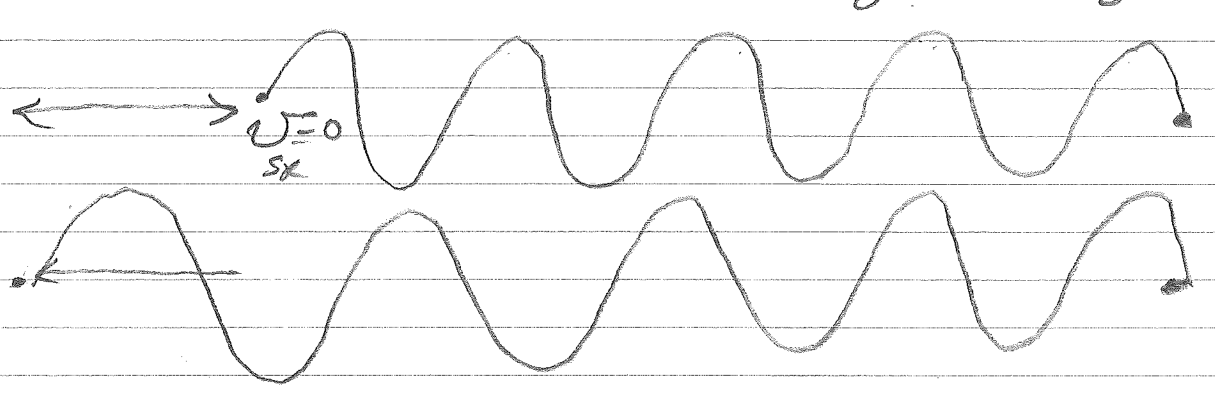
$$\lambda' f' = v \qquad f' = \frac{v}{\lambda'} = \frac{v}{\lambda_0\left(1 - \frac{v_{SR}}{v}\right)} = \frac{f_0}{1 - \frac{v_{SR}}{v}} \uparrow$$

$$\lambda_0 f_0 = v$$

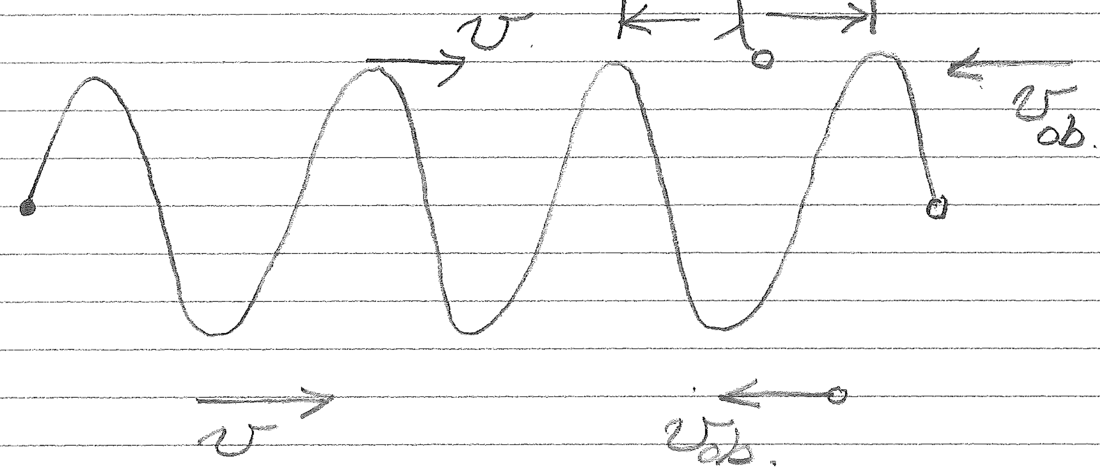
IF SOURCE MOVES AWAY

λ' IS STRETCH OUT

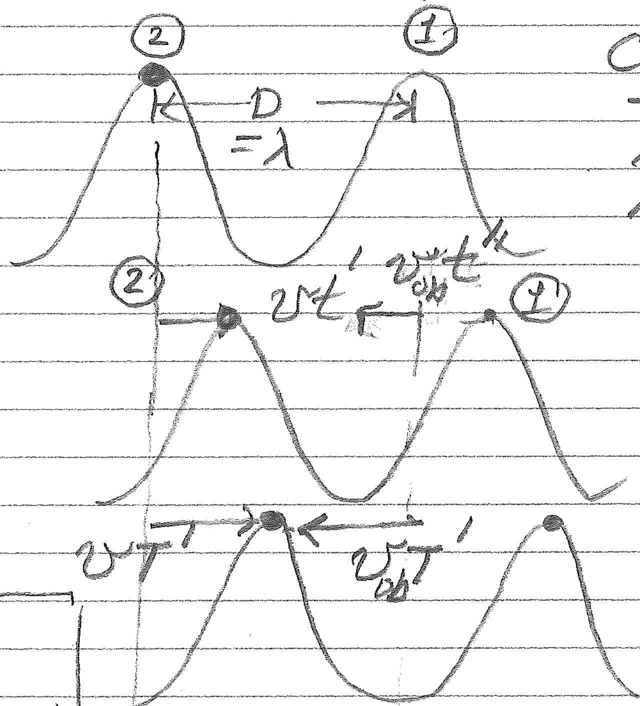
$$\lambda' = \lambda_0\left(1 + \frac{v_{SR}}{v}\right) \qquad f' = \frac{v}{\left(1 + \frac{v_{SR}}{v}\right)\lambda_0} = \frac{f_0}{1 + \frac{v_{SR}}{v}} \downarrow$$



CASE 2 OBSERVER MOVES & SOURCE STATIONARY.



NOTHING HAPPENS TO λ
OBSERVER SEES CREST COMING FASTER THAN WHEN HE/SHE IS NOT MOVING.



CREST 1 ARRIVES AT t IF YOU DON'T MOVE CREST 2 ARRIVES AT $D = \lambda = vt$
$t = T$ PERIOD $= \frac{1}{f}$

T' IS WHEN YOU SEE PEAK 2

$$\underbrace{(v + v_{ob})}_{\text{RELATIVE } v_{REL}} T' = \lambda_0$$

ALSO
$$\lambda f' = V = (v + v_{ob})$$
$$\lambda f' = v\left(1 + \frac{v_{ob}}{v}\right)$$
$$f' = f\left(1 + \frac{v_{obs}}{v}\right)$$

$$T' = \frac{1}{f'} = \frac{\lambda}{v + v_{ob}}$$

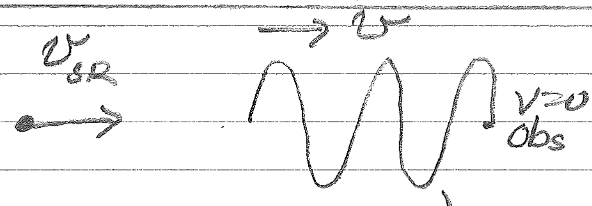
$$f' = \frac{v + v_{ob}}{\lambda_0} = \frac{v}{\lambda_0}\left(1 + \frac{v_{ob}}{v}\right) = f_0\left(1 + \frac{v_{ob}}{v}\right)$$

MOVING AWAY $\quad f' = f_0\left(1 - \frac{v_{ob}}{v}\right)$

Summary of Doppler

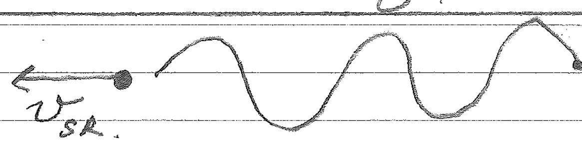
Find the condition — Multiply each

Moving Source



Wave λ compressed

$$f_{v_{SR}} = f_0 \frac{1}{1 - \frac{v_{SR}}{v}}$$



λ stretched

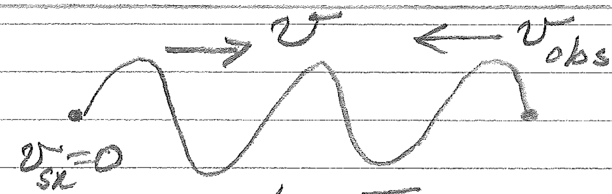
$$f_{v_{SR}} = f_0 \frac{1}{1 + \frac{v_{SR}}{v}}$$

Rescale λ

Same v.

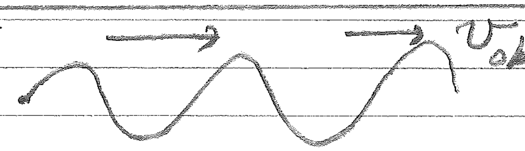
$$\lambda' f' = v$$

Moving Observer



$$T' = \frac{T_0}{1 + v_{obs}/v}$$

$$f_{v_{ob}} = f_0 \left(1 + \frac{v_{obs}}{v}\right)$$



$$T' = \frac{T_0}{1 - v_{ob}/v}$$

$$f_{v_{ob}} = f_0 \left(1 - v_{ob}/v\right)$$

Use same λ

Use $v_{relative}$

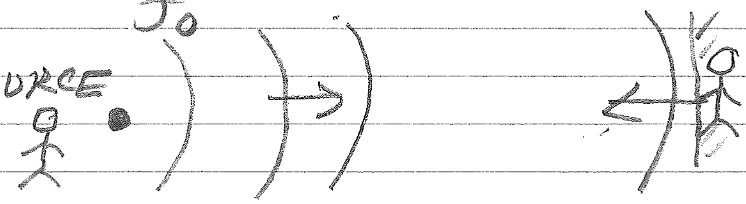
$$\lambda f' = v_{relative}$$

Doppler SHIFT FROM MOVING & REFLECTING WALL

REFLECTING WALL ACTS FIRST AS A MOVING OBSERVER WHICH THEN REEMITS SOUND BACK TO ORIGINAL ORIGIN AS A MOVING SOURCE

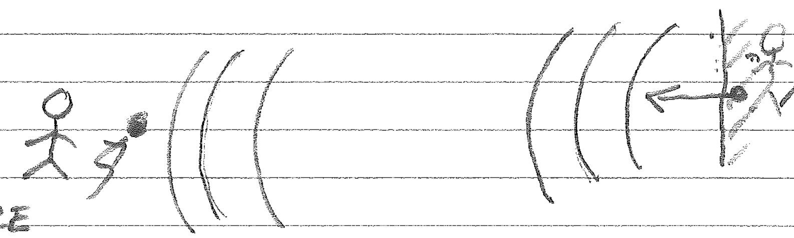
STEP 1 SOURCE

f_0



WALL ACTS AS MOVING OBSERVER, SEES f' BECAUSE OF v_{REL}

STEP 2.



SOURCE IS NOW OBSERVER FOR REFLECTED WAVE

NOW MOVING SOURCE FOR REFLECTED WAVE WITH f'' RELATED TO f'

STEP 1 MOVING OBSERVER TOWARD SOURCE

$$f' = f_0\left(1 + \frac{v_{OBS}}{v}\right)$$

STEP 2. REFLECTED WAVE - MOVING SOURCE TOWARD STATIONARY OBSERVER

$$f'' = \frac{f'}{1 - \frac{v_{SR}}{v}} \qquad v_{SR} = v_{OBS} = v_{OBJECT}$$

$$f'' = \frac{f_0\left(1 + v_{OBJECT}/v\right)}{\left(1 - v_{OBJECT}/v\right)} \simeq f_0\left(1 + \frac{2v_{OBJECT}}{v}\right)$$

IF $v_{OBJECT} \ll v$ $\longrightarrow$ $\dfrac{f'' - f_0}{f_0}\dfrac{v}{2} = v_{OBJECT}$

"BEAT FREQUENCY" ← MISSING ...