Sound

I Sound is a longitudinal wave produced by the compression and rarefaction of matter

A) The speed of sound in air at 25°C is
$V = 331 + (0.6)T(°C)$ $\quad V = f\lambda$
$= 331 \frac{m}{s} + (0.6)(25°C) = 346\ m/s$

B) Produced by vibrating objects
1) Vibrations cause pressure changes in the air. A succession of compressive and rarefactive disturbances in a capable medium
2) Colliding molecules move parallel to the motion of the wave
a) Sound can't travel in a vaccuum b/c there are no molecules to move and collide

C) Sound waves exhibit all wave properties such as diffraction, refraction, reflection, and interference

D) It is elasticity of the medium not density which influences the speed of sound

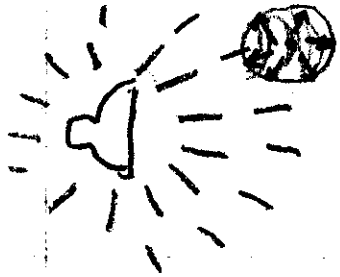
E) The particles in the medium acquire energy from the vibrating source and begin to vibrate.

II Pitch and Loudness

A) Pitch is highness or lowness of a sound
1) Pitch $\propto$ frequency

B) Intensity $\simeq$ Loudness
1) Intensity $\propto$ amplitude
2) Intensity is rate at which energy flows per unit area - $I \propto 1/R^2$
a) Energy rate = Power = Joules/sec = Watt
b) $I = \frac{P}{A}$ $\frac{watts}{m^2}$ $\quad I = 10^{-12} \frac{w}{m^2}$ hearing threshold
$I = 1\ w/m^2$ pain

EXAMPLE – A SPEAKER EMITS SOUND ENERGY AT A RATE OF 50 W. CALCULATE THE INTENSITY LEVEL AT 34 m AWAY FROM THE SPEAKER



THE SOUND WOULD SPREAD OUT SPHERICALLY FROM THE SOURCE $V = \frac{4}{3}\pi r^3$ WHERE THE SURFACE AREA OF THE SOUND $A = 4\pi r^2$ WHERE r IS THE DISTANCE FROM THE SOURCE

$$I = \frac{P}{A} = \frac{50\,W}{(4)(\pi)(34)^2} = 3.44 \times 10^{-3}\ \frac{W}{m^2}$$

C) RELATIVE SOUND INTENSITY IS MEASURED IN DECIBE

$$dB = 10 \log \frac{I}{I_0}$$ WHERE I_0 = HEARING THRESHOLD

$$I_0 = 10^{-12}\ \frac{W}{m^2}$$

– DETERMINE THE dB's OF THE SPEAKER ABOVE

$$dB = 10 \log \frac{3.44 \times 10^{-3}\ W/m^2}{1 \times 10^{-12}\ W/m^2} = 95.4\ dB$$

COMPARE TO TABLE p 273

D) RELATIONSHIP B/W INTENSITY AND LOUDNESS
1) FOR EVERY TEN FOLD INCREASE IN INTENSITY OR dB's, THE APPARENT LOUDNESS DOUBLES.

I	dB
10^{-12}	0
10^{-11}	10
10^{-10}	20
10^{-9}	30
10^{-8}	40
10^{-7}	50

10× INTENSITY; 100×; 1000×; 10,000×
TWICE AS LOUD; TWICE AS LOUD; TWICE AS LOUD; TWICE AS LOUD
4 TIMES LOUDER; 8 TIMES LOUDER; 16 TIMES LOUDER

E) SONIC FREQUENCIES 1) INFRASONIC 10^{-2}Hz - 20Hz
2) AUDIO RANGE 20Hz-20,000Hz 3) ULTRASONIC 20,000 - 10^{9}Hz

III MUSIC AND SOUND
A) TIMBRE THE QUALITY OF SOUND
B) CONSONANCE- COMBINATION (CHORD) OF FREQUENCIES PRODUCING A 'PLEASING' SOUND - OCCURS WHEN FREQUENCIES ARE IN SMALL WHOLE NUMBER RATIOS
(NOISE) C) DISSONANCE - COMBINATION OF f PRODUCING AN 'UNPLEASANT' SOUND
D) FUNDAMENTAL - (1ST HARMONIC) - THE LOWEST RESONANT f OF A SOUND
E) OVERTONES- f's THAT ARE MULTIPLES OF THE FUNDAMENTAL
F) EQUALLY TEMPERED CHROMATIC SCALE
1) OCTAVE-NOTES REPEAT EVERY EIGHT MAJOR STEPS - DOUBLE FREQUENCY
2) SCALE IS BROKEN INTO 12 SECTIONS TO GET NOTES' OR 13 NOTES FROM FUND → OCTAVE

SHARP #(HIGHER) / FLAT b(LOWER)	C	C#/Db	D	D#/Eb	E	F	F#/Gb	G	G#/Ab	A	A#/Bb	B	C
	262	277	294	311	330	349	370	392	415	440	466	494	524

G) LAW OF STRINGS

$f \propto \frac{1}{\text{LENGTH}}$ $f \propto \frac{1}{\text{DIAMETER}}$ $f \propto \sqrt{\text{TENSION}}$

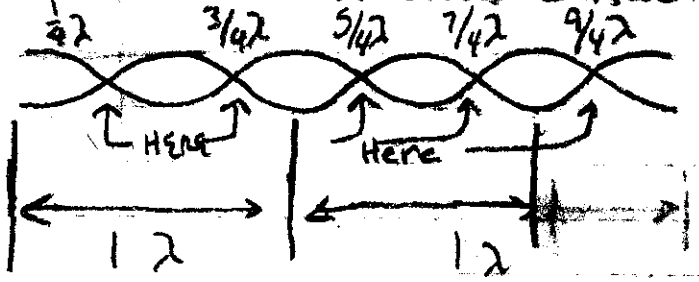
$f \propto \frac{1}{\sqrt{\text{DENSITY}}}$

H) BEAT FREQUENCY- WHEN 2 WAVES OF SLIGHTLY DIFFERENT FREQUENCIES COMBINE CONST & DESTR CREATING A STANDING WAVE SHAPE WAVE

See p 279

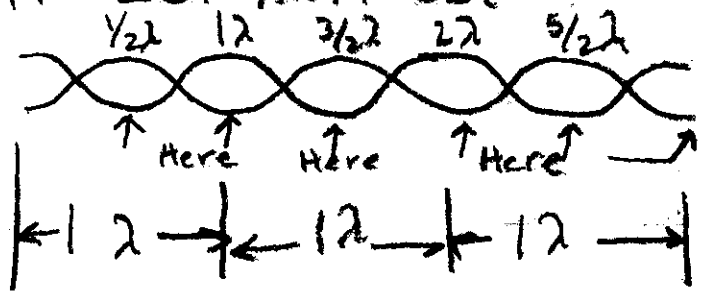
II RESONANCE - INCREASING THE AMPLITUDE OF VIBRATION BY REPEATEDLY APPLYING A SMALL EXTERNAL FORCE AT THE SAME FREQUENCY

A) CLOSED TUBE RESONANCE OCCURS AT $\frac{1}{4}\lambda$, $\frac{3}{4}\lambda$, $\frac{5}{4}\lambda$ etc AT EACH NODE IN THE STANDING WAVE PRODUCED BY THE INCOMING WAVE AND ITS REFLECTION



See p 276

B) OPEN TUBE RESONANCE OCCURS AT $\frac{1}{2}\lambda$, 1λ, $\frac{3}{2}\lambda$, 2λ etc AT EACH ANTINODE



See p 277

V THE DOPPLER EFFECT - APPARENT SHIFT OF FREQUENCY DUE TO MOTION WITH RESPECT TO SOUND

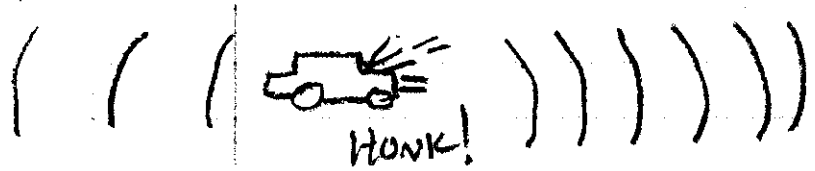
A) SOURCE OF SOUND IN MOTION - OBSERVER STATIONARY

$$f' = \frac{f}{1 \pm \frac{V}{V_s}}$$

← ACTUAL f OF SOUND

V_s = velocity of sound

V = Velocity of Source
− MOVING TOWARDS
+ MOVING AWAY



SOUND WAVES SPREAD OUT LOWER f

SOUND WAVES COMPRESSED HIGHER f

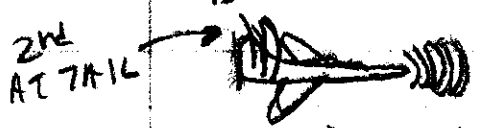
EARTH SEES ALL GALAXIES MOVING AWAY DUE TO RED 'DOPPLER' SHIFT OF THE STAR'S LIGHT

B) OBSERVER IN MOTION

$$f' = f\left(1 \pm \frac{V}{V_s}\right)$$

+ MOVING TOWARDS HIGHER f
− MOVING AWAY LOWER f

V DOUBLE SONIC BOOM



SOURCE MOVING FASTER THAN THE SOUND IT PRODUCES. WAVES INTERFERE CONSTRUCTIVELY AND PRODUCES A BARRIER OF SOUND WAVES. EXTRA THRUST MUST BE USED TO OVERCOME IT. ONCE SUPERSONIC SPEED IS ATTAINED THE BARRIER NO LONGER SLOWS THE AIRCRAFT BUT FOLLOWS IT

A) MACH NUMBER # OF TIMES SPEED EXCEEDES THE SPEED OF SOUND

VI FORCED VIBRATIONS - WHEN A VIBRATING OBJECT IS BROUGHT INTO CONTACT WITH ANOTHER OBJECT CAUSING IT TO VIBRATE AT A FORCED FREQUENCY

SYMPATHETIC VIBRATIONS - VIBRATING OBJECT ALREADY IN CONTACT CAUSING A COUPLED OBJECT TO VIBRATE - GUITAR STRINGS/BODY