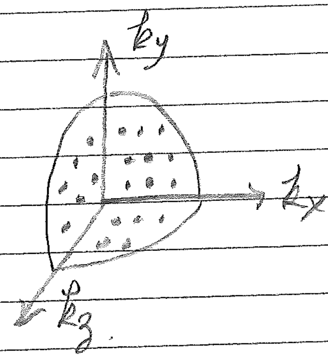
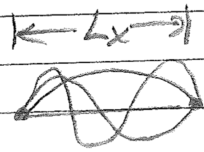
LECTURE 26.
CONTINUATION OF PART OF LECTURE 25

IMPORTANCE OF COUNTING FACTOR $N(k)$

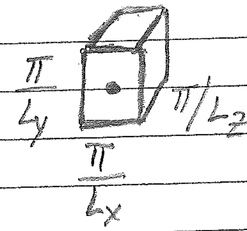
$$N(k) = \frac{1}{8}\frac{4\pi}{3}k^3 \Big/ \frac{\pi^3}{V_{L_xL_yL_z}} \qquad \frac{dN}{dk} = \frac{1}{8} 4\pi \frac{1}{\pi^3} V_{L_xL_yL_z} k^2$$





$n\lambda_x = 2L_x$

$k_x = n\frac{\pi}{L_x}$



FUNDAMENTAL VOLUME PER POINT.

VARIOUS TRANSFORMATIONS

$k \leftrightarrow \lambda$

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

$$N(\lambda) = \frac{4\pi}{3} V_{L_xL_yL_z} \frac{1}{\lambda^3}$$

$$\left|\frac{dN}{d\lambda}\right| = 4\pi V_{L_xL_yL_z} \frac{1}{\lambda^4}$$

USED IN BLACK BODY RADIATION
E&M WAVES IN CAVITIES.

$k \rightarrow f = \frac{v_s}{\lambda}$

$$N(f) = \frac{4\pi}{3} V_{L_xL_yL_z} \left(\frac{f}{v_s}\right)^3$$

QUANTUM

$k \rightarrow p$ MOMENTUM

$p = \hbar k \quad k = \frac{1}{\hbar}p$

$h = 2\pi\hbar$

$$N(p) = \frac{\frac{4\pi}{3} p^3 V_{L_xL_yL_z}}{h^3}$$

NUMERATOR IS CALLED PHASE SPACE -
MOMENTUM × POSITION HAS UNITS OF h.

STATISTICAL MECHANICS

ONE STATE PER h^3 IN PHASE SPACE

$p \rightarrow \epsilon = p^2/2m$

$p = \sqrt{2m\epsilon}$

$$N(\epsilon) = \frac{\frac{4\pi}{3}(2m\epsilon)^{3/2} V_{L_xL_yL_z}}{h^3}$$

$\frac{dN(\epsilon)}{d\epsilon}$ = DENSITY OF STATES

CONTINUATION OF LECTURE 25.

HOW TO USE $N(k)$ AND $\frac{dN(k)}{dk}$ & ITS TRANSFORMATIONS.

$V_{L_x L_y L_z} \equiv V$

BLACK BODY RADIATION

LOOK AT ENERGY BETWEEN λ TO $\lambda + d\lambda$

1) COUNT MODES. $\frac{dN}{d\lambda} = 4\pi V \frac{1}{\lambda^4}$

2) MULTIPLY BY ENERGY OF PHOTON $hf = \frac{hc}{\lambda} = \mathcal{E}_\gamma$

$$4\pi V \frac{1}{\lambda^4} \frac{hc}{\lambda}$$

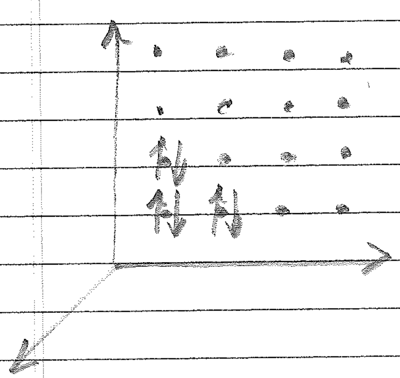
3) MULTIPLY BY OCCUPATION FACTOR THAT PHOTON HAS $\mathcal{E}_\gamma$

$$\frac{1}{e^{\mathcal{E}/k_BT} - 1} = \frac{1}{e^{hc/\lambda k_BT} - 1}$$

4) γ HAS EXTRA FACTOR OF 2 - SPIN OR $\vec{E}$ FIELD HAS TWO $\perp$ DIRECTION POSSIBILITIES WRT $\vec{k}$

$$8\pi V \frac{1}{\lambda^5} hc \frac{1}{e^{hc/\lambda k_BT} - 1}$$ PLANCK DISTRIBUTION

ELECTRONS IN A METAL AT T=0 TEMPERATURE



A EACH POINT PUT ONLY 2 ELECTRONS - ONE SPIN UP ONE SPIN DOWN - PAULI EXCLUSION PRINCIPLE - EXPLAINS PERIODIC TABLE OF ELEMENTS. FIND THE LOWEST POSSIBLE DISTRIBUTION IN ENERGY. LAST FILLED ENERGY IS CALLED THE FERMI ENERGY OR FERMI MOMENTUM P_F

$$N_{\#\,of\,e^-} = \underset{\uparrow\downarrow\,spin}{2} \frac{\frac{4\pi P_F^3}{3} V}{h^3}$$

I.E. FILL A FERMI SPHERE OF RADIUS P_F

$E_F = P_F^2 / 2m$

FERMI PRESSURE SUPPORTS WHITE DWARF STARS

LECTURE 26

ECHOES & REVERBERATION, DESIGN OF CONCERT HALLS

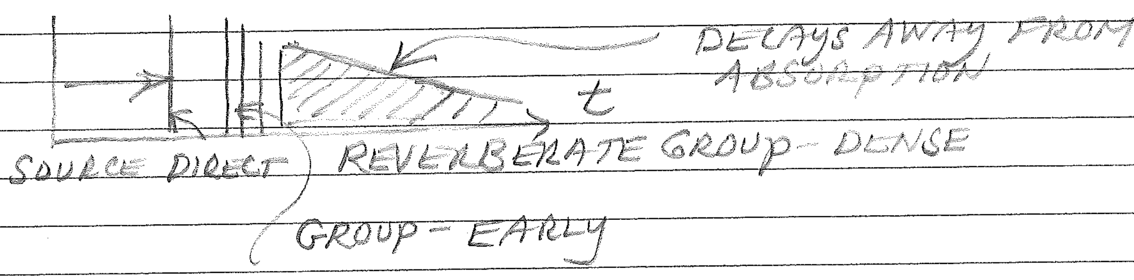
$v_s = 344\ m/s = 1130\ ft/s$

DIRECT SOUND

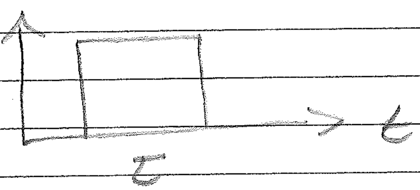
A SOURCE 113 ft AWAY ARRIVES IN 0.1 S = 100 MS
SOURCE 11.3 ft AWAY " " 0.01 S = 10 MS

EARLY SOUND - SHORTLY AFTER ECHOES ARRIVE

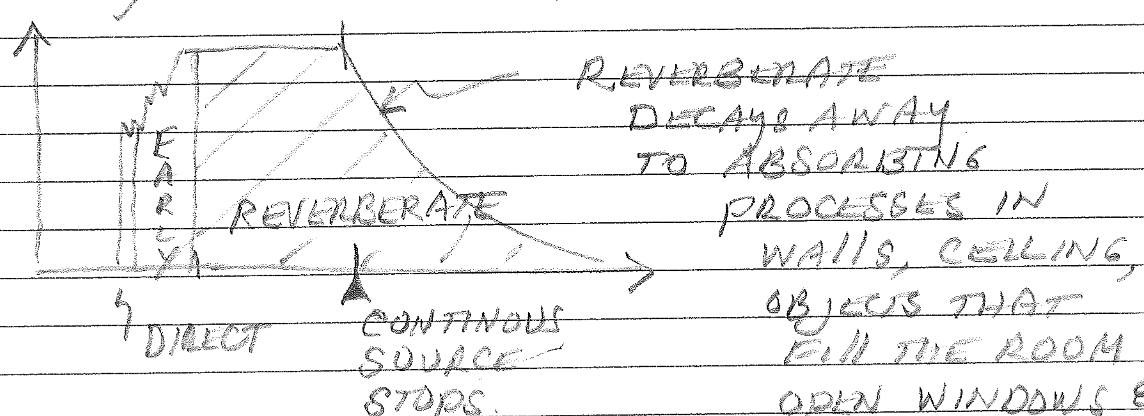
REVERBERATION SOUND: SHORTLY AFTER EARLY ECHOES COME VERY CLOSE TOGETHER - 1000'S CAN ARRIVE WITH SPACINGS AS SHORT AS 0.01 MS TO 1 MS.



CONTINUOUS SOURCE OVER INTERVAL τ



IF SOURCE IS CONTINUOUS REVERBERATE SOUND BUILDS UP TO AN EQUILIBRIUM LEVEL WHERE SOUND ENERGY BEING SUPPLIED = SOUND ENERGY LOST TO ABSORPTION

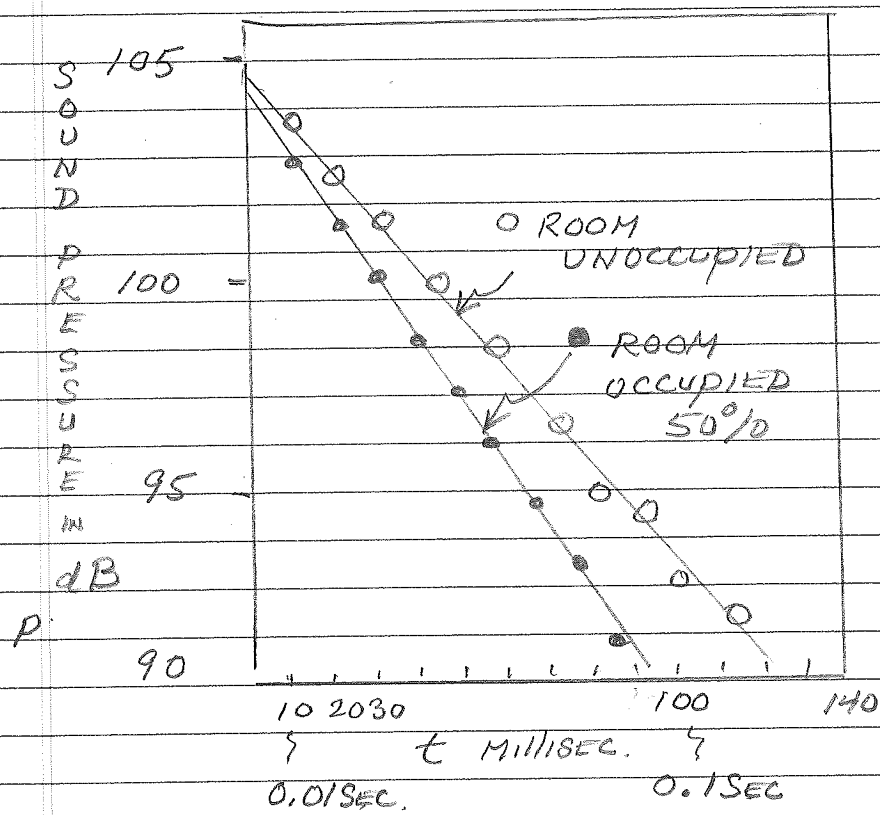


DECAY FOLLOWS AN EXPONENTIAL DECAY LAW

$e^{-\lambda t}$

ECHOES & REVERBERATION

EXPONENTIAL DECAY SEE FIG. 33.4 P 527



P = PRESSURE $\sim Ae^{-\lambda t}$ λ DECAY CONSTANT

$$e^{2.3025} = 10 \quad e = 10^{1/2.305}$$
$$= 10^{.4343}$$

$$P \sim A \cdot 10^{-.4343\lambda t}$$

$$\log_{10} P \sim \log A - .4343\lambda t$$

$$dB = 20 \log_{10} P \sim 20 \log A - 8.686\lambda t$$

STRAIGHT LINE WITH NEGATIVE SLOPE DETERMINED BY DECAY CONSTANT λ.

ABSORPTION: INCREASING OBJECTS THAT ABSORB INCREASES THE DECAY RATE

ECHOES & REVERBERATION

AFTER SOUND SOURCE STOPS REFLECTIONS STILL CONTINUE BUT ABSORPTION LEADS TO A SITUATION NO LONGER IN EQUILIBRIUM.

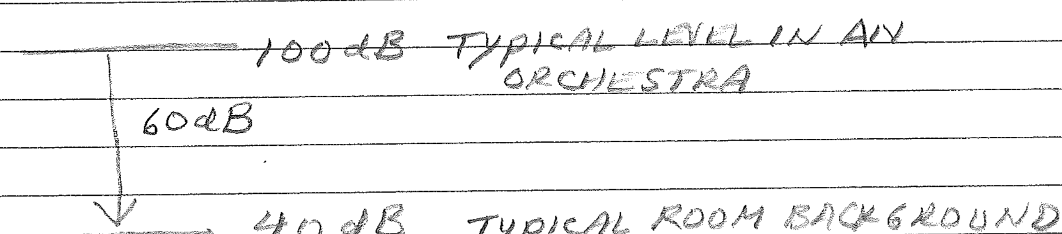
1. IF REVERBERANT SOUND DECAYS TO SLOWLY THE CLARITY OF THE NEXT NOTE IS LOST.
2. IN SPEECH YOU WANT A SHORTER REVERB TIME THAN IN MUSIC. MUSIC LIKES A LONGER REVERB TIME TO GIVE A "LIVELY" FEELING.
3. SOME EXAMPLES: BOSTON SYMPHONY HALL 1.8S; N.Y. CARNEGIE HALL 1.7S. FOR CLASSROOM ~ 1S IS GOOD.
4. A FORMULA USED TO CALCULATE THE REVERBERATION TIME IS DUE TO SABINE CALLED

$$RT_{60} \sim K \frac{\text{VOLUME OR ROOM}}{\text{ABSORPTION AREA}}$$

← V MEASURES AMOUNT OF ENERGY IN ROOM.

AREAS ARE WERE ABSORPTION IS. →

THE T_{60} REFERS TO CHOOSING A REDUCTION OF 60dB IN THE SOUND PRESSURE LEVEL. THE CHOICE OF 60dB



5. PROBLEM WITH LOW FREQUENCIES CALLED BASS LOSS PROBLEM. THE LOW FREQUENCIES NEED A MUCH HIGHER THRESHOLD TO BE HEARD. SEE FIG 6.4 P107. THE THRESHOLD FOR HEARING RISES SIGNIFICANTLY AT LOW f