

$$x = v t$$

$$F = ma \quad \text{Newton's 2nd Law}$$

$$P = F/A$$

$$W = F x$$

$$F = -k x \quad \text{Hooke's Law}$$

$$W = \frac{1}{2} k x^2 \quad (\text{for spring})$$

$$f = \frac{1}{T} = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

$$x(t) = A \sin(2\pi f t + \phi)$$

$$v = c = f \lambda$$

$$c = 332 \text{ (m/s)} \pm 0.6 \text{ (m/s/ } ^\circ\text{C)}$$

$$c = 1087 \text{ (ft/s)} \pm 1.1 \text{ (ft/s/ } ^\circ\text{F)}$$

$$f_{\text{AVERAGE}} = (f_1 + f_2)/2$$

$$f_{\text{BEATS}} = f_1 - f_2$$

$$I = P/A = P/(4\pi r^2) \quad (P = \text{Power})$$

$$\text{SIL} = 10 \text{ Log}(I/I_0)$$

$$I = I_0 \times 10^{L/10} \quad I_0 = 10^{-12} \text{ W/m}^2$$

Conversions:

$$1 \lambda = 360^\circ = 2\pi \text{ radians}$$

$$1 \text{ Hz} = 1 \text{ cycles/sec} = 2\pi \text{ rad/s} = 360^\circ/\text{s}$$

PHYSICAL CONSTANTS

$$\rho = 1.21 \text{ kg/m}^3 \text{ (density of air)}$$

$$\rho = 10^3 \text{ kg/m}^3 \text{ (density of water)}$$

BASIC FORMULAS

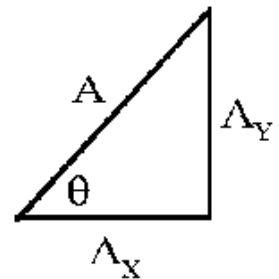
$$\text{Sphere: } A = 4\pi r^2, \quad V = \pi r^3$$

$$\text{Cylinder: } A = 2\pi rL, \quad V = \pi r^2 L$$

$$A_X = A \cos(\theta);$$

$$A_Y = A \sin(\theta);$$

$$\tan(\theta) = A_Y / A_X ;$$



CAUTION:

- pressure is "P", density is rho "ρ"
... and sometimes power is "P"
- acceleration is "a", Area is "A"
- force is "F", frequency is "f",
... and Fahrenheit is "F"

	+0 dB	+1 dB	+ 2 dB	+ 3 dB	+ 4 dB	+ 5 dB	+ 6 dB	+ 7 dB	+ 8 dB	+ 9 dB	+ 10 dB		
120 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-0}$	W/m ²
110 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-1}$	W/m ²
100 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-2}$	W/m ²
90 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-3}$	W/m ²
80 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-4}$	W/m ²
70 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-5}$	W/m ²
60 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-6}$	W/m ²
50 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-7}$	W/m ²
40 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-8}$	W/m ²
30 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-9}$	W/m ²
20 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-10}$	W/m ²
10 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-11}$	W/m ²
0 dB	1.0	1.3	1.6	2.0	2.5	3.2	4.0	5.0	6.3	7.9	10.0	$\times 10^{-12}$	W/m ²

Level Difference	Intensity Ratio
$SIL_1 - SIL_2 =$	I_1 / I_2
0 dB	1.0
1 dB	1.3
2 dB	1.6
3 dB	2.0
4 dB	2.5
5 dB	3.2
6 dB	4.0
7 dB	5.0
8 dB	6.3
9 dB	7.9
10 dB	10.0
20 dB	10^2
30 dB	10^3
40 dB	10^4
50 dB	10^5
60 dB	10^6
70 dB	10^7
80 dB	10^8
90 dB	10^9
100 dB	10^{10}
$(10 \times n)$ dB	10^n

Sound Level dBA	Max 24hr Exposure Occupational	Max 24hr Exposure Non-occupational
80		4 hr
85		2 hr
90	8 hr	1 hr
95	4 hr	30 min
100	2 hr	15 min
105	1 hr	8 min
110	30 min	4 min
115	15 min	2 min
120	0 min	0 min

	<u>Pythagorean</u>	<u>Just</u>	<u>Mean Tone*</u>	<u>Equal</u>
C	0	0	0	0
C#	114	92	76	100
D	204	204	193	200
E_b	294	316	310	300
E	408	386	386	400
F	498	498	503	500
F#	612	590	579	600
G	702	702	696.5	700
G#	816	816	772	800
A	906	884	890	900
B_b	996	996	1007	1000
B	1110	1088	1083	1100
C	1200	1200	1200	1200

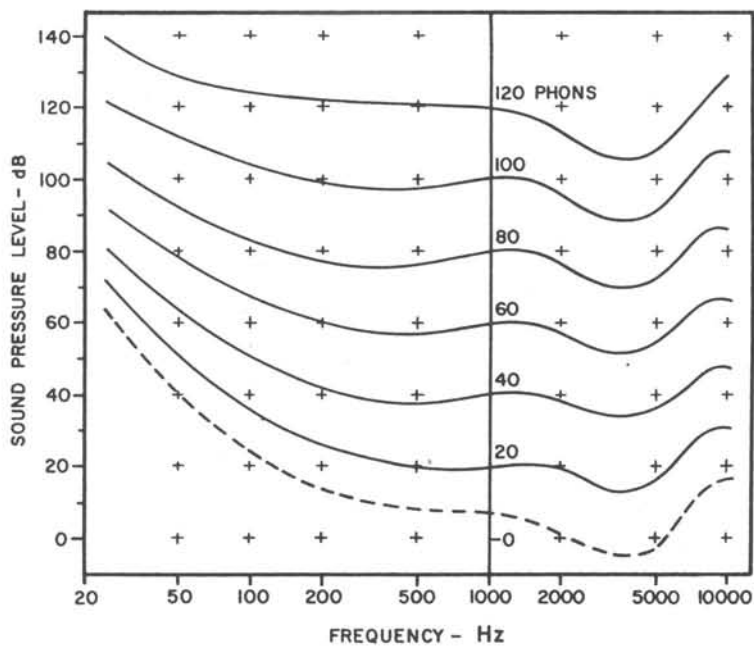


FIG. 3. Sensitivity of the ear as a function of frequency; equal loudness curves relating loudness level in phons to sound pressure level in decibels.

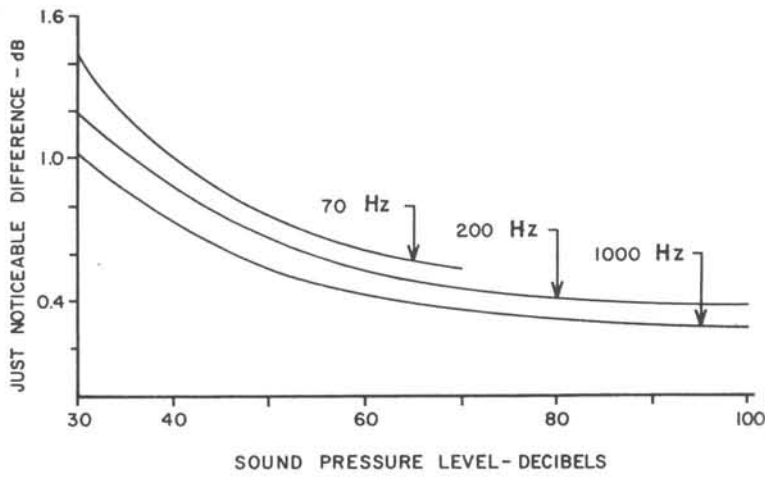


FIG. 2. Just noticeable difference in sound pressure level for three frequencies.

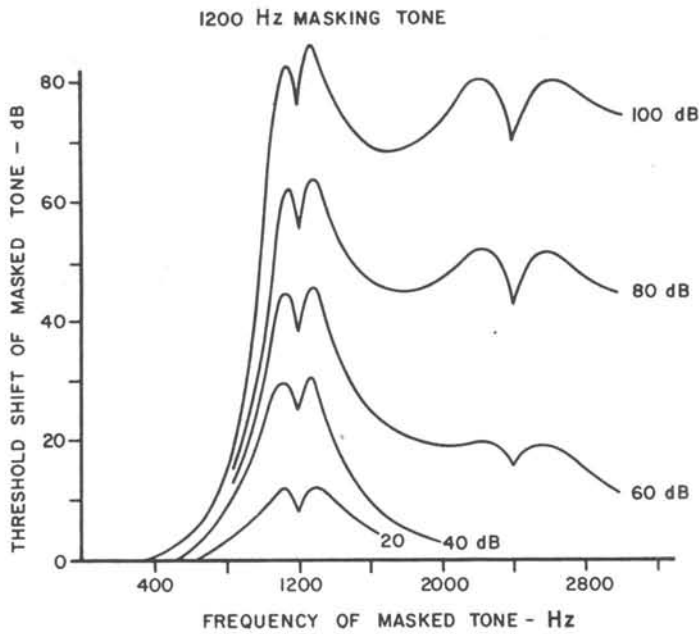
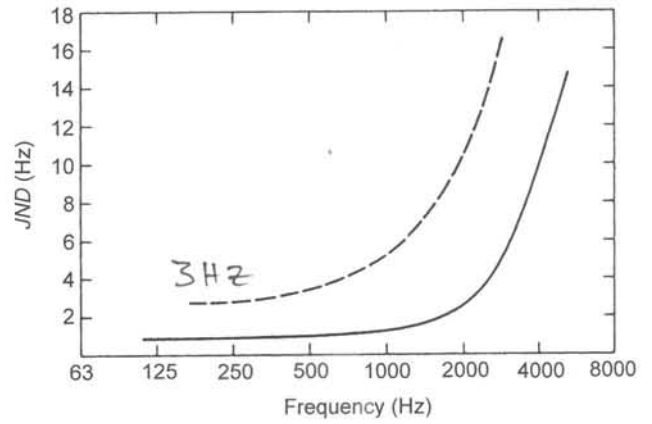


FIG. 5. Masking curves for a masking tone of 1200 hertz.

Sound Level (dBA)	Maximum 24-Hour Exposure	
	Occupational	Nonoccupational
80		4 hr
85		2 hr
90	8 hr	1 hr
95	4 hr	30 min
100	2 hr	15 min
105	1 hr	8 min
110	30 min	4 min
115	15 min	2 min
120	0 min	0 min

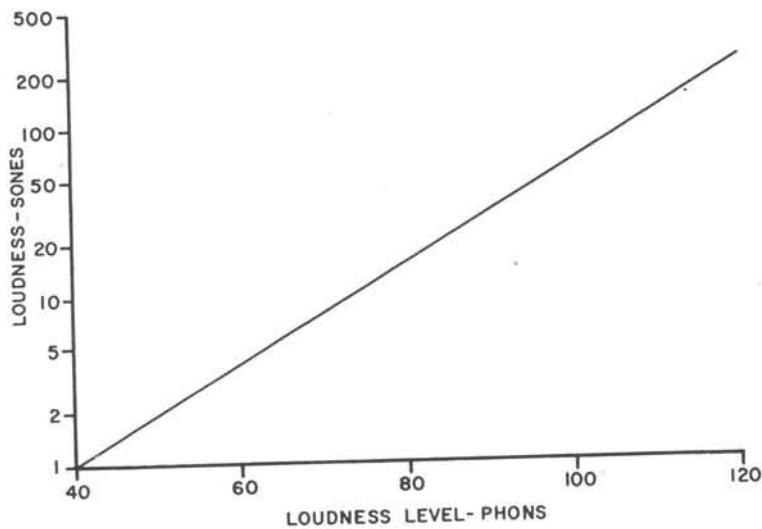


FIG. 4. Relation between loudness in sones and loudness level in phons.

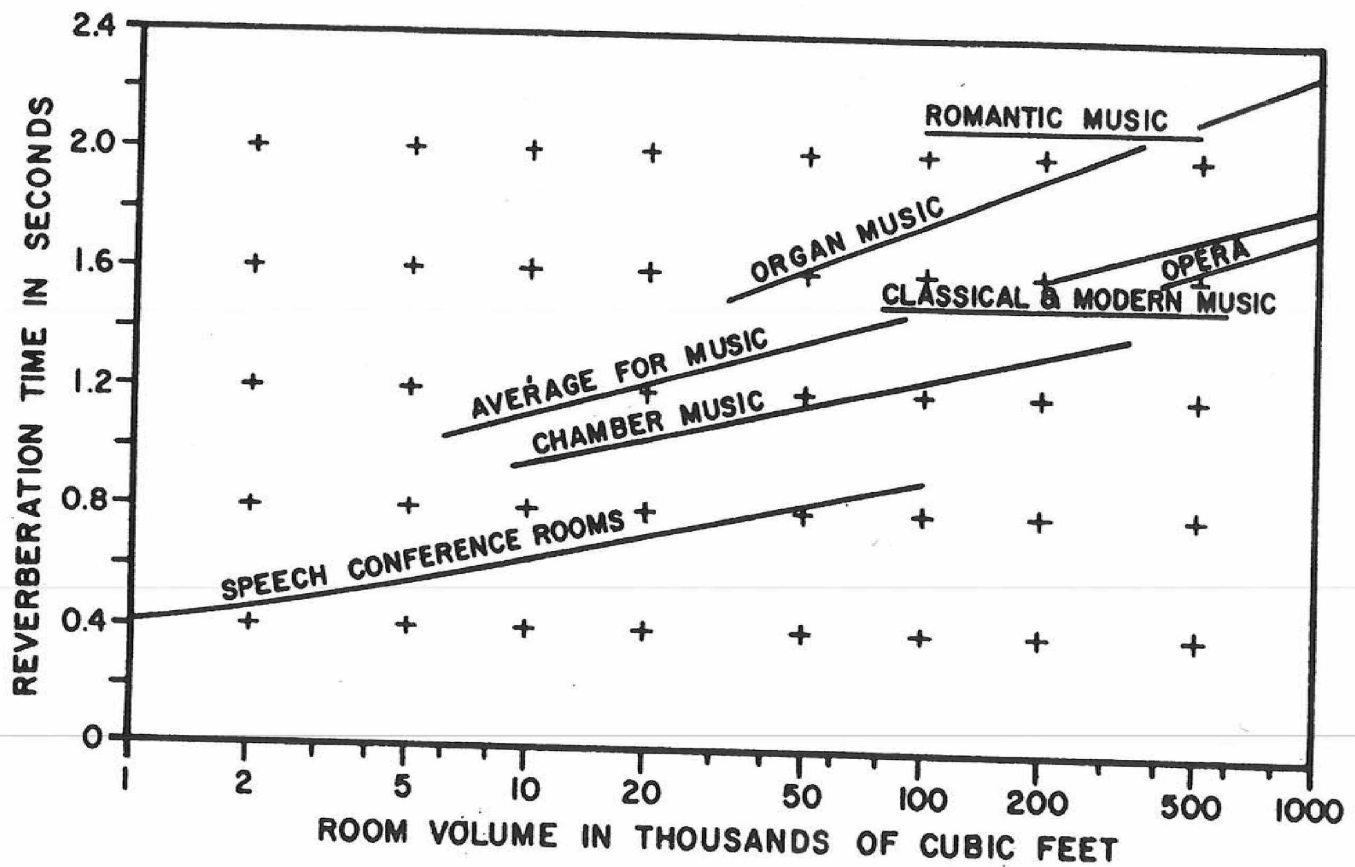


FIG. 5. Optimum reverberation time for auditoriums of various sizes and functions at a frequency of 500 hertz.

	FREQUENCY—HERTZ					
	125	250	500	1000	2000	4000
Marble or glazed tile	.01	.01	.01	.01	.02	.02
Concrete, unpainted	.01	.01	.01	.02	.02	.03
Asphalt tile on concrete	.02	.03	.03	.03	.03	.02
Heavy carpets on concrete	.02	.06	.14	.37	.60	.65
Heavy carpets on felt	.08	.27	.39	.34	.48	.63
Plate glass	.18	.06	.04	.03	.02	.02
Plaster on lath on studs	.30	.15	.10	.05	.04	.05
Acoustical plaster, 1"	.25	.45	.78	.92	.89	.87
Plywood on studs, 1/4"	.60	.30	.10	.09	.09	.09
Perforated cane fiber tile, cemented to concrete, 1/2" thick	.14	.20	.76	.79	.58	.37
Perforated cane fiber tile, cemented to concrete, 1" thick	.22	.47	.70	.77	.70	.48
Perforated cane fiber tile, 1" thick, in metal frame supports	.48	.67	.61	.68	.75	.50