EE 480   Exam #2   NAME: George W. Bush .

November 15, 2004   50 Minutes   *40* points total   OPEN BOOK and NOTES (but no consultants!)
5 problems, 2 pages

SHOW YOUR WORK: Correct answer with no work shown may not receive credit.
Wrong answer with work shown will receive partial credit.

Unless otherwise stated, assume propagation in air, 1 atm, 20°C, c = 343 m/sec $\rho_0 c$ = 415 Pa · sec/m

(1) (6 pts.)
What is the A-Weighting characteristic and why is it used?

A filter characteristic used in sound level meters to mimic the frequency-dependent sensitivity of the human ear for low and medium sound levels. The characteristic is roughly bandpass, centered around 2kHz, and rolling off gradually for lower and higher frequencies. The characteristic is chosen to be approximately the inverse of the 40-phon equal loudness curve.

(2) (8 pts.)
An industrial worker sustains the following noise exposure:

1 hour at 95 dBA
1 hour at 100 dBA

How many hours can this worker now spend in a 90 dBA noise field without exceeding the OSHA industrial noise guidelines? Explain.

See Table 13.11.2 (p. 377)
95dBA dose: 1h / 4h limit
100dBA dose: 1h / 2h limit
*Sum: 0.25 + 0.5 = 0.75. Remaining exposure is 0.25 of limit at 90 dBA, or 0.25*8 =* ***2h.***

(3) (6 pts.)
A voltage of 7 volts (rms) is measured at the output of an audio preamp when a 600Ω load is attached.

a) What is the output level in dBm?

dBm = 10 $\log_{10}(P/1mW)$. *P =* V^2/R *= 81.7mW. Output level is 10* $\log_{10}(81.7)$ *=* ***19.1dBm***

b) What is the output level in dBV?

dBV = 20 $\log_{10}(V/1V)$. *Output level is 20* $\log_{10}(7)$ *=* ***16.9dBV***

c) What is the output level in dBu?

dBu = 20 $\log_{10}(V/0.775V)$. *Output level is 20* $\log_{10}(7/0.775)$ *=* ***19.1dBu***

(4) (10 pts.)

A rectangular room has floor dimensions 10 meters by 20 meters, and a ceiling height of 3 meters. The room has a "Floor, wooden", and the walls are "Concrete Block, no paint" (refer to Table 12.5.1 in the textbook).

(a) Find the Sabine reverberation time (T_{60}) at **500 Hz** if the ceiling absorptivity is 0.02 .

$T_{60} = 0.161\ V / A$ At 500 Hz, $a_{floor} = 0.1$, $a_{block} = 0.3$; $V = 10 \times 20 \times 3 = 600\ m^3$

'A' = $S_{floor}a_{floor} + S_{walls}a_{block} + S_{ceil}a_{ceil} = 200(0.1) + 180(0.3) + 200(0.02) = 78$ sabin

$T_{60} = 0.161(600)/78 = 1.24$ seconds

(b) What is the fractional change in T_{60} at 500 Hz if the ceiling absorptivity is now increased to 0.99?

'A' now becomes $200(0.1) + 180(0.3) + 200(0.99) = 272$ sabin

T_{60} reduced by the factor $78/272 = 0.29$

(5) (10 pts.)

A loudspeaker mounted in a large rigid baffle behaves approximately like an ideal baffled piston radiator. The driver's radius is 0.127 meters.

a) What is the lowest frequency for which a **near field** pressure null occurs on-axis at the surface of the driver (r=0)? Explain your work.

See eqn. 7.4.11, p. 180. When approaching the loudspeaker from a large distance, the first local minimum (null) occurs at r_2 given by: $r_2/a = a/2\lambda - \lambda/2a$.

r_2 = zero, so $a/2\lambda = \lambda/2a$, which implies that $\lambda = a = 0.127$ m.

$f = c/\lambda = (343 m/s) / (0.127\ m) = 2.7$ kHz

b) What is the lowest frequency for which *two* **far field** pressure nulls occur between 0° and 90° in the off-axis beam pattern? What are the two off-axis null angles at this frequency? Explain your work.

Consider fig. 7.4.4, p. 183: as frequency increases for a given driver size, the number of nulls will increase. The minimum frequency with two nulls corresponds to ka = null[2] = 7.02.
Since a = 0.127, $\omega = c\,(7.02) / a$, and $f = c\,(7.02) / (2\pi a) = 3.02$ kHz

Nulls are at $\theta_2 = 90°$ and at solution to $ka \sin(\theta_1) = null[1] = 3.83$. $\theta_1 = 33°$.