Section 1: Questions (12 points)

Q1. Regularly spaced, open holes in an air column introduce a ________ frequency above which sound loss is large and resonances are weak. This affects the ________ of a woodwind instrument, giving these instruments their characteristic sound.

Q2. Percussion instruments involve a wide range of vibrating systems, including: rectangular steel bars (e.g., __________), shaped wooden bars (e.g., __________), tubes (e.g., __________), membranes (e.g., __________), plates (e.g., __________), and parts of oil drums (e.g., __________).

Q3. Because the modes of oscillation of most of the percussion instruments are not simply related to a lowest frequency, they are said to have ________ pitch.

Q4. Bars, membranes, and plates vibrate in natural ________ of oscillation that cannot be described in terms of ________ (i.e., integer multiples) of a lowest ________ frequency.

Q5. An ________ is a device in which a small amount of input power controls a larger amount of output power. The ratio of the output voltage to the input voltage for this device is called its voltage ________. If this remains constant, the amplifier is said to have a ________ characteristic.

Q6. A ________ ________ uses Faraday's law of induction to convert sound waves into electrical vibrations.

Q7. A ________ ________ uses the principle of the voltage across a charged capacitor to create its signal.

Q8. Multiple speaker systems have a ________ network designed to send the high frequencies to a ________ and the low frequencies to a ________.

Q9. For a loudspeaker to radiate sound efficiently, especially at low frequency, it must be mounted on a ________ that reduces ________ between sound waves radiated from the front side and the rear or back side of the speaker.

Q10. Signals from various audio sources are input into a ________ that accepts each signal and produces an output of the appropriate amplitude for subsequent input to an amplifier.

Q11. The most common directional microphone is the ________ microphone.

Q12. A loudspeaker converts electrical energy into ________ energy and radiates it as ________ energy. The percentage of electrical energy radiated as sound is the ________ of the speaker. For direct radiation (cone) speakers, the efficiency is about ________ %; for horn speakers it is ________ %.
Section 2: Problems (10 points)

P1. The volume of air that must be moved by a loudspeaker cone radiating 0.10 W of acoustical power at 50 Hz = \( \square \) cm\(^3\). [See Fig. 19.3 in Rossing, page 424.] To displace this volume, the cone of 12-inch (30 cm) diameter speaker would have to move axially \( \square \) cm.

P2. The design of loudspeakers and their enclosures must include the wave features of sound, including constructive and destructive interference. Consider a loudspeaker 20 cm in diameter mounted at the center of a 1.0 m square baffle board. For the bare speaker with no baffle, the frequency at which the path length from front-side center to back-side center is equal to half the wavelength of sound is \( \square \) Hz. For the speaker mounted on the baffle board, the frequency at which the path length from front-side center to back-side center is equal to half the wavelength of sound is \( \square \) Hz.

P3. Suppose the electrical input power for a speaker is 1.0 W and the output sound power is 0.01 W. The ratio of the output sound power to the input electrical power = \( \square \) and the overall efficiency of the speaker = \( \square \) %.

P4. If a microphone has a sensitivity \( V/P = 1.5 \) mV/Pa, the voltage sensitivity \( S_v = \square \) dBV. In use with a singer generating a sound pressure level of 102 dB, the microphone output voltage \( V = \square \) V. [Use \( SV = 20 \log (V/P) \) and \( L_p = 20 \log (P/P_0) \), where \( P_0 = 2.0 \times 10^{-5} \) N/m\(^2\).]

P5. For a preamplifier with identical input and output impedances, we may define its voltage gain \( G \) as the ratio of output voltage to input voltage. Since power is proportional to (voltage)\(^2\), the power gain = (voltage gain \( G \))^\(^2\) and the preamp power gain in dB = 20 log (\( G \)). For a preamp with a voltage gain \( G = 50 \), the signal power level is boosted by \( \square \) dB.

P6. For an amplifier that has a harmonic distortion of 1%, the ratio \( (V_{\text{harmonics}}/V_{\text{fundamental}}) = 0.01 \). If we think of the harmonic-distortion component of the signal as noise, then this corresponds to a ratio \( (V_{\text{signal}}/V_{\text{noise}}) = 100 \). The signal-to-noise ratio in dB, \( S/N(dB) = 20 \log (V_{\text{signal}}/V_{\text{noise}}) = \square \) dB.

P7. The power transferred from a microphone to a preamplifier if the microphone voltage is 2 mV and the impedance of the preamplifier is 300 \( \Omega \) is \( \square \) W.

P8. The power transferred from a microphone to a preamplifier if the microphone voltage is 1.5 V and the impedance of the preamplifier is 50,000 \( \Omega \) is \( \square \) W.

P9. The power transferred from a power amplifier to a loudspeaker if the amplifier voltage is 10 V and the speaker impedance is 8 \( \Omega \) is \( \square \) W.

P10. A certain amplifier has a voltage gain of 100 and a current gain of 50. Since power = voltage \( \times \) current, we say that the power gain factor = \( \square \). By analogy with an expression for sound power level (dB gain = 10 log \( W_2/W_1 \)), this corresponds to a power gain level = \( \square \) dB.