

Question I (40 points)

Consider a case where there is a machine that generates noise and a receiving point P located at a distance r [m] from the machine, as shown in Fig. 1. When the machine is operated once, starting from the time t_1 , the noise reaches its maximum at time t_2 and stops at time t_3 . Note that the machine is installed on an acoustically rigid plane and can be regarded as an omnidirectional point source.

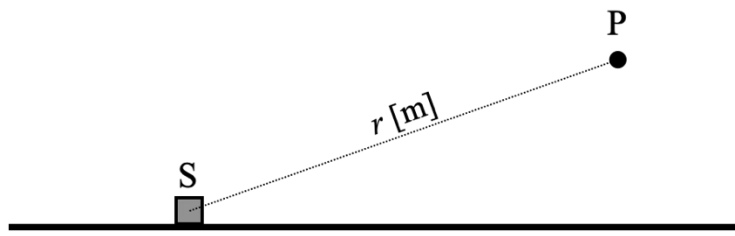


Fig.1

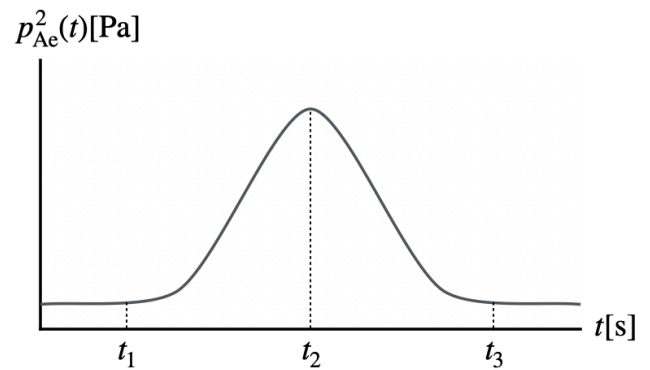


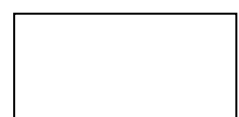
Fig.2

- (1) For a single operation of this machine, the time variation of the square of the effective value of the A-weighted sound pressure at the receiving point P, $p_{Ae}(t)^2$, was observed as shown in Fig. 2. Answer the expression of the maximum A-weighted sound pressure level $L_{Amax,P}$ at the receiving point P in terms of the effective value of the A-weighted sound pressure $p_{Ae}(t_2)$ at time t_2 and the reference sound pressure $p_0 (= 2 \times 10^{-5}$ [Pa]).

<Answer>

- (2) How can the single event sound exposure level $L_{EA,P}$ at the receiving point P be expressed for the single operation of this machine? Answer the expression using the time variation of the effective value of A-weighted sound pressure $p_{Ae}(t)$, p_0 , t_1 , t_3 , and the reference time $T_0 (= 1$ [s]). Note that the difference between the A-weighted sound pressure level at times t_1 and t_3 and the maximum A-weighted sound pressure level is assumed to be 10 dB or more.

<Answer>



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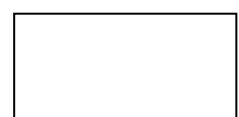
Question I (Continued from previous page)

- (3) Move this machine on the plane and place it at a distance r' [m] from the receiving point P. Answer the expression of the single event sound exposure level $L_{EA,P}'$ at the receiving point P using the single event sound exposure level before the movement ($L_{EA,P}$) and the distances r, r' . Show your answer including the derivation process. Note that the distance between the machine and the receiving point is sufficiently far apart, and the wavefront can be assumed to be a plane wave.

<Answer>

- (4) Assume that this machine operates N times in 10 minutes at a distance r' [m]. In this case, answer the expression of the A-weighted equivalent continuous sound pressure level over the 10-minutes period $L_{Aeq,10min}$ at the receiving point P using the single event sound exposure level before the movement ($L_{EA,P}$), distances r, r' , and the number of operations N in 10 minutes period. Show your answer including the derivation process.

<Answer>



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Question II (15 points)

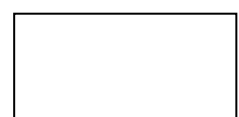
The amplitude-modulated sound $Y(t)$ produced by a sine wave can be expressed by the following equation.

$$Y(t) = A\{1 + A_m \cos(2\pi f_{\text{mod}}t)\} \cos(2\pi f_c t),$$

where t represents time [s], f_{mod} represents the modulation frequency [Hz], and f_c represents the carrier frequency [Hz]. A is the amplitude of the carrier wave, and A_m is a constant representing the modulation degree ($0 < A_m \leq 1$). Explain the psychoacoustical properties of roughness, which is the subjective impression perceived from such sounds. In your answer, specifically mention the relationship between the modulation frequency and the carrier frequency, and include the following keywords.

Keywords: modulation frequency, carrier frequency, modulation degree, critical bandwidth

<Answer>



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Question III (25 points)

S. S. Stevens proposes four levels as scales for quantifying human senses: nominal scales, ordinal scales, interval scales, and ratio scales.

(1) Briefly explain the properties of each level and the applicability and limitations of mathematical processing.

<Answer>

(2) Give examples of evaluations using each level of scale in subjective evaluation of sound.

<Answer>



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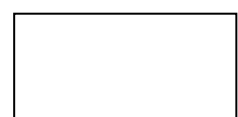
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Question IV (50 points)

Answer the following questions about perceived loudness.

- (1) A formula for estimating loudness has been proposed and standardized internationally as ISO 532. The ISO 532 was revised in 2017. Prior to the revision, the Stevens method and the Zwicker method were described, but after the revision, the Zwicker method and the newly adopted Moore-Glasberg method were included. Both calculation methods are based on the relationship between loudness and the physical quantity of sound. Other characteristics of the auditory system are also taken into consideration. List two of these characteristics and explain how they relate to loudness.

<Answer>



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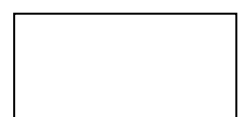
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- (2) Explain the relationship between loudness and physical sound quantity using equations. Explain the symbols used in the equations.

<Answer>

- (3) Using the relationship in (2), calculate the change in loudness that would occur if the sound pressure level of a pure tone at 1 kHz were to increase by 20 dB. Show your calculation process in your answer. You may use $\log_{10}2 = 0.3$ if necessary.

<Answer>



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Question V (30 points)

Answer the terms that apply to the underlined parts (a) to (o) in the following explanations of noise assessment.
For (a) and (o), provide the relevant laws, and for (n), provide the applicable numerical value.

- The Environmental Quality Standards for Noise are based on the provisions of the (a)_____ and set standards for environmental conditions related to noise that should be maintained in order to preserve the (b)_____ and contribute to the protection of (c)_____ .
- The current Environmental Quality Standards for Noise use the (d)_____ as a metric for assessing noise, with standard values set for each (e)_____ and time period.
- As a general rule, locations that are considered representative of the noise in the target area are selected for evaluation in general areas. However, when evaluating noise in areas (f)_____ , the percentage of households exceeding environmental standard values is used instead. This is known as a (g)_____ evaluation.
- When measuring (d)_____ , use a sound level meter that meets the conditions specified in the Measurement Law, and use an (h)_____ correction filter to correct the frequency.

<Answer>

(a) _____

(b) _____

(c) _____

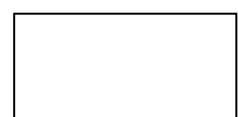
(d) _____

(e) _____

(f) _____

(g) _____

(h) _____



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- One of the effects of exposure to noise is hearing loss. Exposure to loud noise can cause a (i) _____, but recovery from this is relatively quick. However, repeated exposure over a long period of time can lead to a (j) _____, which is more difficult to recover from.
- The (j) _____ is classified as (k) _____ hearing loss because it is caused by the degeneration or destruction of hair cells in the inner ear. (l) _____ hearing loss, on the other hand, is caused by abnormalities in the outer ear, eardrum, ossicles, etc.
- The effect of noise on hearing is evaluated using the (m) _____, which is measured in decibels (dB). This is the difference between an individual's minimum audible threshold when listening to pure tones and that of a normal ear.
- A typical early symptom of hearing loss caused by long-term exposure to noise in the workplace is an increase in (m) _____ around (n) _____ Hz.
- From the perspective of preventing occupational hearing loss caused by noise, the (o) _____ defines harmful noise-related work.

<Answer>

(i) _____

(j) _____

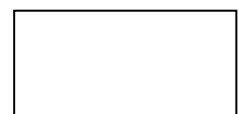
(k) _____

(l) _____

(m) _____

(n) _____

(o) _____



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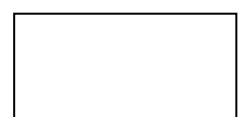
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Question VI (40 points)

Answer the following questions about the concept of soundscape proposed by Canadian composer Raymond Murray Schafer.

- (1) Explain the circumstances that led Schafer to propose the concept of soundscape, and his related activities, to the best of your knowledge.

<Answer>



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(2) Explain the definition of soundscape as described in Handbook for Acoustic Ecology, edited by Barry Truax (1978).

<Answer>

(3) Explain the name of the method for understanding the environment according to the definition in (2). Furthermore, Schafer stated that when perceiving the sonic environment in this manner, the extracted sounds can be classified into three categories. Answer these categories.

<Answer>

