Name: _____ Date: _____ Period: _____

Fighting Noise with Noise — Regents Practice

Practice cluster in the format of the NYS Regents Examination in Physical Science: Physics. Companion to the reading passage "Sound Waves & Active Noise Cancellation".
Base your answers to questions 1 through 6 on the information below and on your knowledge of Physical Science: Physics. Some questions may require the use of the 2025 Edition Reference Tables for Physical Science: Physics.

Fighting Noise with Noise

On a long flight, the steady drone of the jet engines fills the cabin. Active noise-cancelling (ANC) headphones reduce this noise by adding more sound. Sound is a longitudinal wave: a pattern of compressions (higher air pressure) and rarefactions (lower air pressure) moving through the air. A small microphone on each ear cup detects the incoming noise. A processor then drives a speaker inside the ear cup to produce an "anti-noise" wave. Where the two waves overlap at the ear, they superpose, and the combined pressure variation can be much smaller than the noise alone.

Model 1 (described in words): A graph of air-pressure change versus time shows the engine hum at the listener's ear. The wave is a smooth sine curve with an amplitude of 0.20 Pa and a frequency of 120 Hz. It starts at 0 Pa at t = 0 ms, rises to +0.20 Pa at t = 2.1 ms, returns to 0 Pa at 4.2 ms, falls to −0.20 Pa at 6.3 ms, and returns to 0 Pa at 8.3 ms. Sound travels through the cabin air at 343 m/s.

1 In the box below, sketch one cycle (0 ms to 8.3 ms) of the anti-noise pressure wave that the speaker must produce to cancel the engine hum in Model 1 as completely as possible. Label the maximum and minimum pressure values. [1]

Pressure change (Pa) ↑

0 ——————————————————→ time (ms)

2 Substitute numerical values into a mathematical representation that can be used to determine the wavelength of the engine hum in the cabin air. [1]

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Engineers tested a pair of ANC headphones on a model head with a microphone inside each ear. They played four recorded sounds and measured the sound level at the ear, first with ANC turned off and then with ANC turned on. The difference between the two readings is the noise reduction, measured in decibels (dB). On the decibel scale, each decrease of 10 dB means the sound intensity has decreased to one-tenth of its earlier value. The results are shown in Table 1.

Table 1: Noise Reduction with ANC Turned On

Sound Source	Frequency (Hz)	Behavior of Sound	Noise Reduction (dB)
A: Jet engine hum	120	steady, constant	15
B: Air-conditioner fan	250	steady, constant	14
C: Sudden siren	2,500	sudden, unpredictable	2
D: Crying infant	1,000–3,000	rapidly changing pitch	3

Data are representative values for practice.

3 A student claims that the 15-dB reduction for the jet engine hum means the intensity of the hum reaching the ear was reduced by only about 70%. Place a check mark (✓) in either the Support or Refute box below to indicate if the given information supports or refutes the student's claim. Justify your response with evidence from the passage and Table 1. [1]

☐ Support ☐ Refute

Justification:

_____

_____

_____

4 Which statement best describes the pattern in the data in Table 1?

(1) The headphones reduce steady, low-frequency sounds the most.
(2) The headphones reduce high-frequency sounds the most.
(3) The headphones reduce all four sounds by about the same amount.
(4) The headphones reduce sudden sounds the most because sudden sounds carry the most energy.

The anti-noise wave is useful only if it reaches the ear at the right moment. Together, the microphone, processor, and speaker delay the anti-noise wave by about 0.10 ms. Engineers could shorten this delay with faster processors, but faster processors drain the battery more quickly. Instead, most designs combine ANC with padded ear cups, which block high-frequency sounds well but block low-frequency sounds poorly.

5 Which mathematical representation can be used to determine the period of the siren sound, Source C?

(1) $T = 1 \div (2{,}500\ \text{Hz})$
(2) $T = (343\ \text{m/s}) \div (2{,}500\ \text{Hz})$
(3) $T = (2{,}500\ \text{Hz}) \div (343\ \text{m/s})$
(4) $T = (2{,}500\ \text{Hz})(343\ \text{m/s})$

6 Using the 0.10-ms delay, explain why the anti-noise wave can effectively cancel the 120-Hz engine hum but cannot effectively cancel the 2,500-Hz siren. [1]