"Робототехніка. 5-9 клас", "STEM. 5-9 клас», «Фізика та основи техніки. 7-9 клас" (кількість навчальних годин визначається закладом освіти) [1].

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RESEARCH TASKS IN ACOUSTICS

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Tasks in physics are the problems, which, respectively, need various types of logical reasoning, mathematical operation and experiment, and then, promote the formation of learners' thinking. Korshak [1] identified three types of physics tasks depending on how solutions are discovered: computational, experimental and logical tasks. Research tasks include characteristics of all these three types of physics tasks.

In our work we offer examples of research tasks in acoustics. To solve these problems, students must be able to analyze formulas (tasks 1), solve atypical problems (task 2), understand natural phenomena (task 3), have knowledge of wildlife (task 4), understand the structure of devices and perform experimental measurements (task 5).

Task 1.

If the temperature of air is -8 °C, what is the speed of sound that travels through it?

Solution:

The speed of sound in air is 331.5 m/s at temperature 0 °C. The speed of sound increases with temperature about 0.6 m/s per 1°C.

The speed of sound in air is given by formula:

$$v = 331.5 + 0.6 \times T \quad (1),$$

where T is the temperature in °C.

Using equation (1) we get:

v = 326.7 m/s.

Task 2.

Why does sound in air travel faster in summer than in winter?

Solution:

The speed of sound in air is given by formula:

$$v = 331.5 + 0.6 \times T \text{ (2)},$$

where T is the temperature in °C.

We consider only the physical content without analysis of phenomena in the Earth's atmosphere. It is clear that temperatures are positive in summer and negative in winter. Using equation (2) we can argue that the speed of sound at positive temperature is greater than the speed at negative temperature.

Task 3.

If thunder is heard in 5 seconds after a lightning flash, how far away is a thunderstorm when the temperature of air is +21 °C?

Solution:

Lightning and thunder are produced at the same instant. Speed of light is so high the lightning is practically seen at the same instant when it occurs.

The speed of sound in air is given by formula:

$$v = 331.5 + 0.6 \times T \text{ (3)},$$

where T is the temperature in °C.

Using equation (3) we get:

v = 344.1 m/s.

We consider the movement of sound to be uniform.

In this case, the distance D from the observer to the lightning is given by formula:

$$D = v \times t \text{ (4)},$$

where t = 5 s.

Using formula (4) we get:

D = 1720.5 m.

Task 4.

What are the dimensions of objects whose positions can be determined by bats using their sonar with a sound frequency of 100,000 Hz? Dolphins also use frequencies up to 100,000 Hz. What are the minimum sizes of objects that dolphins can detect?

Solution:

Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing. This limit varies from person to person and is approximately 20,000 Hz in healthy young adults.

The wave equation relates the speed of the wave v to its frequency f and wavelength λ:

$$v = f \times \lambda \text{ (5)}$$

Using equation (5) we get:

$$\lambda = \frac{v}{f} \text{ (6)}$$

The speed of ultrasound in air is equal to 343.5 m/s at the temperature +20 °C.

Using equation (6) we get:

$\lambda = 3.4 \times 10^{-3}$ m.

Approximately these sizes are insects of interest to bats.

The speed of sound in water depends on both temperature and salinity. We use typical tabular data: 1500 m/s.

Using equation (6) we get:

$\lambda = 1.5 \times 10^{-2}$ m.

A dolphin can spot a small fish.

Task 5.

It is known that tuning fork is set on resonance box for strengthening of sound vibrations. Air in box and tuning fork varies in acoustic resonance. What determines the length of the resonance box?

Solution:

The wave equation relates the speed of the wave v to its frequency f and wavelength λ:

$$v = f \times \lambda \ (7)$$

Using equation (7) we get:

$$\lambda = \frac{v}{f} \ (8)$$

The speed of sound in air is given by formula:

$$v = 331.5 + 0.6 \times T \ (9),$$

where T is the temperature in °C.

According to formula (9), the speed of sound is equal to 343.5 m/s when the temperature of air is +20 °C.

The frequency of tuning fork is equal to 440 Hz.

Using equation (8) we get: $\lambda = 0.78$ m.

Minimum length l of air resonant column is equal to 1/4 wavelength of the sound in air. In this case, minimum length l of air resonant column is equal to 0.19 m. The obtained result was checked by means of experimental measurements.

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