

# Development of an Achievement Test for the 6<sup>th</sup> Grade Sound and its Properties Unit<sup>¶</sup>

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**Abstract:** *In this study, it was aimed to develop an achievement test taking into account the subject acquisitions of the sound and properties unit in the sixth-grade science course. In the test development phase, firstly, literature review for the study was conducted. Then, 30 multiple choice questions in align with the subject acquisition in the 2018 science curriculum. This 30-question test was presented to opinion of three academicians and a science teacher for the validity of the test. Necessary adjustments were made in line with the opinions of the experts. Subsequently, the draft test, modified according to the experts' feedback, was applied to a total of 300 seventh-grade students. After the analysis, the number of questions in the test was reduced to 27. As a result of item analysis, mean difficulty index value of the test was 0.41, and item discrimination index was 0.49. The reliability analysis for the developed test was found 0.92 by calculating the KR-20 reliability coefficient value. By considering, the validity and reliability analysis results, it was concluded that the final version of the developed test, grounded in Bloom's Taxonomy, is a valid and reliable test with different difficulty levels.*

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## **Introduction**

**S**CIENCE is a significant natural science that enable us to inquire how the universe and nature go through a process and what their functions are. From past to present, many researchers have investigated the concepts in students' minds about various phenomena. Some of them prove that student concepts and scientific knowledge are inconsistent, while some of them think otherwise (Celeon & Subramaniam, 2010). It is seen that the concepts in science are not directly associated with events, principles and tangible concrete objects or experiences time to time. This situation especially causes primary school children who have not yet passed to the abstract stage to be unable to construct the concepts in science subjects in a meaningful way. Therefore, this situation indicates that most of the subject concepts in science are cognitive and theoretical concepts. Also, when looked at the subject-concepts in the sound and its properties unit, it is seen that it has an abstract property (Aksoy & Özcan, 2020). It is also known that most of the science subjects are related to daily life. Although the unit of sound and its properties is a subject from daily life, how sound is formed, the void environment, the materialized environment, how sound does not propagate in a void environment, the speed of sound or microscopic scale explanations remain abstract for students. Therefore, there are serious difficulties in structuring the knowledge in this unit. In the study conducted by Demirci and Efe (2007) students confuse the formation of sound with the propagation of sound and think that sound propagates in an immaterialized environment. They think that sound stops as a result of encountering an obstacle. For this reason, this situation has attracted the attention of many researchers and various researches have been deemed appropriate by the researchers. Yanar et al. (2019) developed a test related to the light and sound unit in their study. The study was applied to 200 students in a secondary school in Kayseri. As a result of the statistical analysis, one question was removed and a test consisting of 19 items in total was prepared. Consequently, a test that can be used in scientific studies and teachers' evaluation processes was prepared. According to the study conducted by Küçük et al., (2021) the opinions of science teachers as to the teaching of the 6th grade sound and its properties unit were taken. In this study, a case study, which is one of the qualitative research designs, was used. The opinions of 39 science teachers were taken in total. As a result of the analysis, although the teachers interpreted the sound topics as easy to understand and the unit was oversimplified, it was concluded from the teachers' statements that the students had difficulty in understanding and structuring the subject concepts. In the study conducted by Akson et al. (2023) it was investigated how design-based activities affect the knowledge and attitude levels of the sound and its properties unit. According to the results of the study, it was determined that design-based activities positively

affected students' achievement in the sound and its properties unit. There are also some studies on misconceptions related to sound and properties unit (Dinçer & Özcan, 2016; Kistak, 2014; Wild, et al., 2013). Additionally et al. (2019) conducted research on how sound and its properties are represented. Studies have also been conducted on how sound is modeled in students' minds (Yüzbaşıoğlu, 2018).

When some of the studies conducted above are investigated, the most important issue in learning is to reveal the meaningful learning status. The main goal is to increase the achievement of students by providing meaningful learning. Therefore, the teacher, who has an important place in the system, has a crucial duty and responsibility. The teacher need to observe the achievement of the student, notice the change in his/her achievement, analyze the change in order to observe it better, and provide the required conditions for meaningful learning (Özcan, et al., 2019).

For all these, the measurement and assessment system manage to determine what extent the students have learnt the acquisitions and concepts. Still, the students' incorrect and incomplete knowledge is revealed thanks to measurement and evaluation (Metin, 2013). In addition, teachers, in the measurement and assessment process, serve with the purposes of providing feedback to students, increasing students' motivation, evaluating the effectiveness of programs when necessary, and improving teaching processes (Sabancı & Yazıcı, 2017). In this respect, it is ensured that students make healthy decisions about their professional future (Akarsu, 2018). Therefore, it is important for teachers to know how and in what way to make reliable-valid assessment for an effective measurement and assessment (Newfields, 2016; Korkmaz & Kaptan, 2005; Sabancı & Yazıcı, 2017). Nowadays, tests consisting of multiple-choice items are especially preferred in making decisions in teaching in measurement and assessment (Kartz & Slomka, 1999). The reasons of this preference are that there is no time and space restriction during the application of multiple-choice items so that many participants can be tested in a short time. Moreover, the questions can be asked from cognitive levels from knowledge to analysis level by increasing the number of items and options. This also increases the content validity, and most significantly, scoring can be done easily and in a short time (Öksüz & Güven-Demir, 2019). When national-international studies in the literature are investigated, it is seen that achievement tests that are suitable for the acquisitions in various units related to science have been developed (Yalınkılıç & Gül, 2023; Kargin & Gül, 2021). After these studies are examined, it is also seen that tests, suitable for the target acquisitions in the sound and its properties unit, were developed (Aksoy & Özcan, 2020). On the examination of the literature, it is seen that the sound and its properties unit was given together with the light unit in the science subjects of the sixth grade in the past curricula (Yanar, et al., 2019). The reason of this is that the studies which were

carried out before the 2018 science curriculum. In the 2013 science curriculum, for the sixth grade, light and sound subjects were included in the same unit and there are three learning acquisition for the subject of sound. However, in the 2018 curriculum, just one unit is allocated to the subject of sound and it is stated that nine target learning acquisitions need to be comprehended under four subtopics. Therefore, when the studies conducted before 2018 are examined, it is seen that since the unit of sound and its properties is within the scope of the unit of light and sound according to the 2013 program, the tests developed were prepared in accordance with the outcomes of these two subjects (Yazıcıoğlu, 2017; Aydın & Kömürkaraoğlu, 2016; Şener-Çoruhlu, et al., 2016; Bakırcı, et al., 2015; Evrekli, et al., 2012). One of the studies on sound and its properties based on the science curriculum after 2018 was developed by Aksoy et al. (2023).

## ***Purpose of the Research***

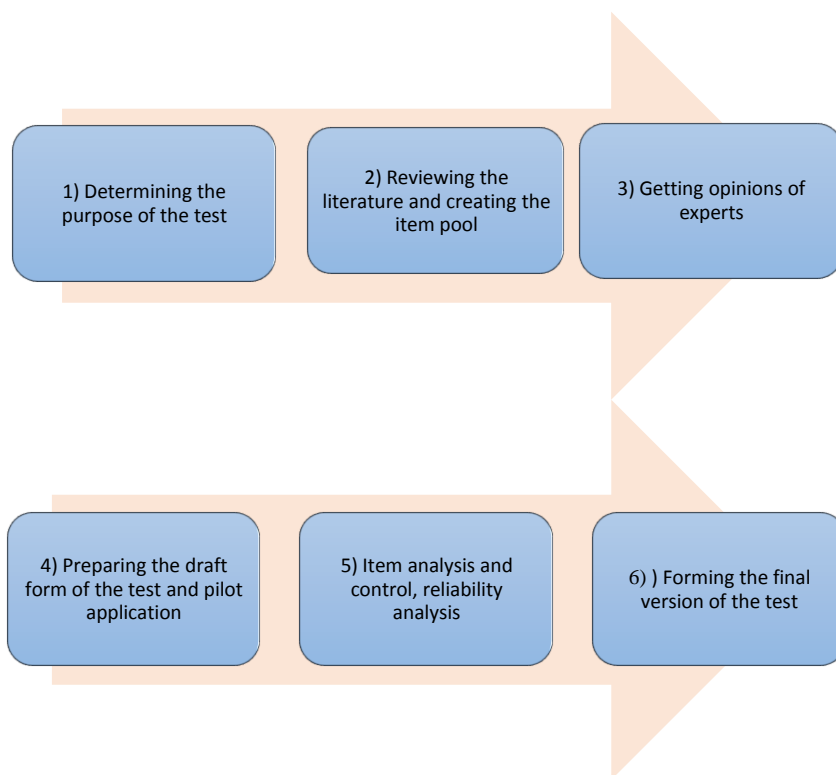
On account of limited number of achievement tests related to the unit of sound and its properties after the 2018 science curriculum was published, it was aimed to prepare a valid reliable achievement test for the sixth grade. Thus, it is aimed to objectively measure the acquisitions-concepts in the unit of sound and its properties. For this purpose, answers to the following questions were sought.

Is the achievement test (SPAT), developed for determining the sixth grade students' achievement levels, valid? Is the achievement test (SPAT), developed for determining the sixth grade students' achievement levels, reliable?

## **Methodology**

### ***Procedures***

In this study, an achievement test was prepared to determine the level of academic achievement of sixth grade secondary school students within the scope of sound and its properties unit. The validity and reliability of the study were tested and analyses were performed. In line with the acquisitions of the 2018 science curriculum (Ministry of National Education [MoNE], 2018), the test items were created inspired by the question banks (test books) of various publications. The relevant questions banks were prepared within the framework of sample questions developed by the Ministry of National Education [MoNE]. At first, expert opinion was taken for the questions determined for the test, and then a pilot study was conducted with 300 students. After that, validity-reliability and item analyses of the test were conducted. Ethical approval for this research was obtained from Harran University Eth-



**Figure 1. Development Stages of SPAT.**

ics Commission dated 16.06.2023 and numbered 2023/88. Kızıkan and Bektaş (2018) argue that the processes to be followed in the development process of a test should be as given in **Figure 1**. SPAT was also developed by following this process.

### ***Research Model***

This study was conducted with the survey method based on the quantitative research paradigm. According to McMillan and Schumacher (2010) survey method is considered appropriate for obtaining information about individuals' attitudes, demographic characteristics, ideas, behaviors, beliefs, values, habits, etc. Therefore, in this study, the survey method was used to develop an academic test that determines students' achievement levels.

### ***Participants***

While determining the participants of the study, the convenience sampling method, which is a type of the purposive sampling method, was selected. The convenience sampling method should be selected in accordance with the research (Kadioğlu, 2019). Some of the most important purposes of choosing the convenience sampling method are that it facilitates researchers in terms of time, labour, cost and application (Fraenkel, et al., 2012). The participants of this research is a total of 300 students studying in a public school in Haliliye district of Şanlıurfa province, which is in the South East Anatolia Region, during the 2023-2024 academic year. However, a total of 270 students were taken into consideration for item analysis.

## ***Research Instruments***

### **The Development of the Achievement Test**

In the study, SPAT was developed in order to determine the level of students' academic achievement on the subject of sound and its properties. Sound and its properties unit consists of four subtopics as sound propagation, different hearing of sound in different environments, speed of sound and finally interaction of sound with matter. During the preparation phase of the SPAT, the test items were developed and selected by considering the questions inspired by the test books which were developed by taking into account the sample unit acquisition and comprehension questions that published by MoNE. Immediately after the questions were determined, it was asked to a science teacher working in MoNE and three experts in the field of science to prepare the table of specification. In this way, their opinions were taken in terms of content validity. It was also considered that the experts in the field of science had more than one year of professional experience and had studies in the field of science education. While the opinions of the experts were taken for the SPAT, the question related to the acquisition was asked and they were asked to indicate whether this acquisition represented the question or not. In addition to this, their opinions on the cognitive level of the question and grammar of the question were also taken.

Within the light of the feedback from the experts and teacher, the questions that did not match the acquisitions in the sixth grade sound and its properties unit were regulated. In addition, grammatical structure and the cognitive levels of the questions were asked to the experts and the required optimizations were made by considering the suggestions of the experts. The question 12, which was regulated as an example by taking into account the opinions of the experts regarding the acquisitions, the cognitive level and grammatical structure of the determined questions, is given in **Table 1**.

According to the experts' opinions, as the root of the question 12, which is an example of the adjusted questions as given in **Table 1**, has a

**Table 1. An Example of Questions Adjusted in Line with Expert Opinion.**

Initial form of the question			Final form of the question		
Experiment	Environments where sound propagates	Environments where sound does not propagates	Experiment	Environments where sound propagates	Environments where sound does not propagates
1	Outer space	Air	1	Outer space	Air
2	Bottle filled with water	Vacuum-sealed glass bowl	2	Bottle filled with water	Vacuum-sealed glass bowl
3	Wall	Outer space	3	Wall	Outer space
4	Vacuum-sealed glass bowl	Wall	4	Vacuum-sealed glass bowl	Wall
<p>According to the table, the environments in which some sound propagates and does not propagate are given. Accordingly, in which of the numbers are the environments mismatched?</p> <p>A) 1 and 4 B) Only-3 C) 1 and 2 D) Only-4</p>			<p>According to the table, some environments in which sound propagates and does not propagate are given. Accordingly, in which of the numbers are the environments mismatched?</p> <p>A) 1 and 4 B) Only-3 C) 1 and 2 D) Only-4</p>		

**Table 2. Acquisitions and Related Questions in the Sound and Its Properties Unit of the 2018 Science Curriculum.**

Acquisition No	Acquisition	Question #
1	S.6.5.1.1. Students will be able to predict the environment in which sound can propagate and test their predictions.	9, 10, 12, 13, Removed-25*, 26
2	S.6.5.2.1. Students will be able to discover by experimenting that sounds are heard differently when the sound source changes.	2, 8
3	S.6.5.2.2. Students will be able to discover by experimenting that sound is heard differently with the change of the environment in which it propagates. The concept of frequency will not be mentioned.	21, Removed-27*
4	S.6.5.3.1. Students will be able to compare the speed of sound in different environments.	1, 3, 4, 5, 11, 14, 15, 16, 17, 22, Removed-24*, 29
5	S.6.5.4.1. Students will be able to give examples of reflection and absorption of sound	6, 18, 28, 30
6	S.6.5.4.2. Students will be able to make predictions to prevent the spread of sound and tests their predictions	23
7	S.6.5.4.3. Students will be able to explain the importance of sound insulation. Technological and architectural applications developed for sound insulation will be mentioned.	20
8	S.6.5.4.4. Students will be able to give examples of acoustic applications. Applications in modern and cultural architecture will be emphasized. For example, the acoustics architecture of the Süleymaniye Mosque will be referred.	7
9	S.6.5.4.5. Students will be able to design an environment that will serve as an example of sound insulation or acoustic applications	19

\*Represents the items removed from the test as a result of the analysis carried out on the process of the test development.

grammatical error in expression, the necessary corrections were made and the question was given its final form. In line with the opinions of experts, warnings regarding other questions were taken into consideration and necessary evaluations were made in forming the final version of the test.

**Table 2** shows the acquisitions and related questions in the sound and its properties unit of the 2018 science curriculum. The questions 24, 25 and 27 were marked with “R” (removed). These questions were removed from the test because the values of these questions were calculated insufficient in the item analysis.

As proved in **Table 2**, all of the items in the item pool that was created during the test phase have been optimized into a level that can be applied to students, by ensuring the face validity of the test. According to the revised Bloom taxonomy stated by Andersen et al. (2001), the question 24 of the test is at the factual knowledge-remember level. The questions of 1-6-7-8-9-10-22-25-26-28-30 are at the conceptual knowledge understood level. The questions of 3-4-5-11-14-16-18-20-21-27-29 are at the conceptual knowledge-apply level. The questions of 2-12-15-17-19-23 are at the conceptual knowledge- analyze level and the question 13 is in the conceptual knowledge evaluate level. The developed test was conducted with the total of 300 seventh grade students. For the pilot application, the test was carried out in 40-minute period during a lesson. Before, carrying out the pilot application, students were informed that it was not intended to give any grades and that data was only collected for a research. As a result of the pilot application, the data gathered from 270 students were included in the analysis. Then, all necessary analysis for validity, reliability and item analyzes were carried out. **Table 3** shows the acquisitions in the unit of sound and its properties in the science curriculum and the cognitive level of the questions including these acquisitions.

When **Table 3** is examined in detail, in the developed for the first learning acquisition within the scope of the sound and its properties unit, there are questions 9, (R) 25, 26, which are at the level of conceptual knowledge for acquisition and at the level of understand for the question; the question 10 is at the level of conceptual knowledge- apply; the question 12 is at the level of conceptual knowledge- analyze; the question 13 is at the level of conceptual knowledge and evaluate. For the second acquisition, the question 8 is at the level of conceptual knowledge- understand and question 2 at the level of conceptual knowledge-analyze. Considering the third acquisition, the questions 21 and (R) 27 are at the conceptual knowledge- apply level. For the fourth acquisition, while the question (R) 24 is at factual knowledge-remember level; question 1 is at conceptual knowledge-remember level; the question 22 is at the conceptual knowledge- understand level; the questions 3, 4, 5, 11, 14, 16, 29 are in the conceptual knowledge- apply level and the question 15 is at the conceptual knowledge-analyze level. For the fifth acquisition,

**Table 3. Table of Indicators According to the Renewed Bloom Taxonomy.**

Cognitive Process Dimension	Remembering				Understanding				Apply				Analyze				Evaluate				Create			
	FK	CK	PK	MK	FK	CK	PK	MK	FK	CK	PK	MK	FK	CK	PK	MK	FK	CK	PK	MK	FK	CK	PK	MK
S.6.5.1.1. Students will be able to predict the environment in which sound can propagate and test their predictions.	-	-	-	-	-	9, 25, 26	-	-	-	10	-	-	-	12	-	-	-	13	-	-	-	-	-	-
S.6.5.2.1. Students will be able to discover by experimenting that sounds are heard differently when the sound source changes.	-	-	-	-	-	8	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
S.6.5.2.2. Students will be able to discover by experimenting that sound is heard differently with the change of the environment in which it propagates.	-	-	-	-	-	-	-	-	-	21, 27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.6.5.3.1. Students will be able to compare the speed of sound in different environments.	24	1	-	-	-	22	-	-	-	3, 4, 5, 11, 14, 16, 29	-	-	-	15	-	-	-	-	-	-	-	-	-	-
S.6.5.4.1. Students will be able to give examples of reflection and absorption of sound	-	-	-	-	-	6, 8	-	-	-	18	-	-	-	23	-	-	-	-	-	-	-	-	-	-
S.6.5.4.2. Students will be able to make predictions to prevent the spread of sound and tests their predictions	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.6.5.4.3. Students will be able to explain the importance of sound insulation.	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.6.5.4.4. Students will be able to give examples of acoustic applications	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.6.5.4.5. Students will be able to design an environment that will serve as an example of sound insulation or acoustic applications	-	-	-	-	-	-	-	-	-	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-

FK: Factual Knowledge, CK: Conceptual Knowledge, TK: Transactional Knowledge, MK: Metacognitive Knowledge.

sition, the questions 6 and 28 are at conceptual knowledge- understand level; the question 18 is at the conceptual knowledge-apply level, and the question 23 is at the conceptual knowledge analyze level. For the sixth acquisition, there is just the question 30 at the conceptual knowledge- understand level. For the seventh acquisition, there is question 20 in the conceptual knowledge- apply level. For the eighth acquisition, there is question 7 in the conceptual knowledge-understand level and for the ninth acquisition, there is question 19 in the conceptual knowledge-analyze level.

## **Results**

In this study, the difficulty index ( $P_j$ ) and item discrimination index ( $r_{jx}$ ) values of each item were calculated to ensure the validity of the test (**Table 4**). In the literature, the discrimination index takes value between -1 and +1. When this value approaches zero, it means that there is a problem in distinguishing the upper and lower groups of the item. The value closes to +1 means that the discrimination is high. On the other hand, when the item discrimination index takes the value (-), it is interpreted that the lower group is more than the upper group in the number of respondents and this situation does not serve the desired purpose (Kubiszyn & Borich, 2003). The item difficulty index shows the correct answer rate for each item in the test and takes values between 0 and 1. As a result of the analysis, if the value is close to 0, the item is quite difficult, and if it is close to 1, the item is interpreted as quite easy (İlhan & Hoşgören, 2017).

According to Çalık and Ayas (2003) items with item difficulty index ( $P_j$ )  $\leq 0.29$  are very difficult, items with 0.30-0.49 are moderately difficult, items with 0.50-0.69 are easy, and items with 0.70-1.00 are very easy. Besides, items with item discrimination index ( $r_{jx}$ )  $\geq 0.40$  are very good and do not need to be edited, items with a  $r_{jx}$  of 0.30-0.40 indicate that the item is very good and does not need to be edited, items with a  $r_{jx}$  of 0.20-0.30 indicate that the item can be used when necessary or advised to be changed, items with a  $r_{jx}$  of  $\leq 0.20$  indicate that the item can be edited or advised to be used, and finally, items with a  $r_{jx}$  of zero or negative values indicate that the item is not recommended to be included in the test. With regard to criteria that mentioned above, the items with a discrimination index below 0.30 (24, 25, 27) were removed from the test in this study. Moreover, when the difficulty index was analyzed, the values below 0.29 for the items (24, 25 and 27) were excluded from the test because of being in the “very difficult” group. The remaining 27 items were included in the test as they were in good, medium, very good values in terms of discrimination and difficulty

As a result of the item analysis, it is seen that this 27-item test covers all the acquisitions related to the subject in the science curriculum. The mean difficulty index of the overall SPAT was calculated as 0.41 and the mean

**Table 4. Item Difficulty and Item Discrimination Index Values in the Development Process of the SPAT.**

Q	G	A	B	C	D	Empty	Full	(Pj)	(rjx)
1	Upper	2	10	5	55*	0	30	0,47	0,56
	Lower	5	30	23	14	0	30		
2	Upper	2	2	48*	20	0	30	0,42	0,48
	Lower	7	17	13	35	0	30		
3	Upper	44*	10	13	5	0	30	0,36	0,48
	Lower	9	21	26	16	0	30		
4	Upper	2	5	18	47*	0	30	0,39	0,51
	Lower	6	22	34	10	0	30		
5	Upper	4	10	12	46*	0	30	0,38	0,5
	Lower	19	16	27	10	0	30		
6	Upper	4	6	12	50*	0	30	0,41	0,55
	Lower	15	25	22	10	0	30		
7	Upper	5	48*	7	12	0	30	0,4	0,51
	Lower	24	11	33	4	0	30		
8	Upper	18	5	2	47*	0	30	0,4	0,5
	Lower	23	24	14	11	0	30		
9	Upper	1	2	4	47*	0	30	0,4	0,5
	Lower	30	10	21	11	0	30		
10	Upper	4	49*	12	7	0	30	0,42	0,51
	Lower	17*	12	22	21	0	30		
11	Upper	6	8	8	50*	0	30	0,45	0,47
	Lower	21	19	16	16	0	30		
12	Upper	44*	7	14	7	0	30	0,37	0,47
	Lower	10	23	16	23	0	30		
13	Upper	6	7	8	51*	0	30	0,45	0,5
	Lower	14	22	24	15	0	30		
14	Upper	6	53*	7	6	0	30	0,49	0,48
	Lower	6	18	21	27	0	30		
15	Upper	6	42*	16	8	0	30	0,35	0,45
	Lower	19	9	28	16	0	30		
16	Upper	6	41*	17	8	0	30	0,34	0,45
	Lower	18	8	25	21	0	30		
17	Upper	0	2	17	53*	0	30	0,48	0,5
	Lower	14	19	22	17	0	30		
18	Upper	49*	12	6	5	0	30	0,43	0,5
	Lower	13	25	17	17	0	30		
19	Upper	0	8	20	44*	0	30	0,37	0,47
	Lower	18	18	26	10	0	30		
20	Upper	5	7	13	47*	0	30	0,4	0,5
	Lower	17	19	25	11	0	30		
21	Upper	13	6	4	49*	0	30	0,42	0,5
	Lower	29	18	13	12	0	30		
22	Upper	11	45*	9	7	0	30	0,38	0,47
	Lower	26	11	28	7	0	30		

23	Upper	2	49*	16	5	0	30	0,42	0,51
	Lower	26	12	25	9	0	30		
24	Upper	41	12	9	10*	0	30	0,23	0,04
	Lower	38	22	5	7	0	30		
25	Upper	15	13*	32	12	0	30	0,27	0,08
	Lower	19	7	25*	21	0	30		
26	Upper	54*	8	7	3	0	30	0,47	0,54
	Lower	15	20	18	19	0	30		
27	Upper	24	26	12*	10	0	30	0,26	0,06
	Lower	23	17	7	25	0	30		
28	Upper	15	44*	7	6	0	30	0,38	0,45
	Lower	23	11	18	20	0	30		
29	Upper	51*	13	6	2	0	30	0,47	0,47
	Lower	17	26	17	12	0	30		
30	Upper	12	0	54*	6	0	30	0,48	0,52
	Lower	21	19	16	16	0	30		

\* Refers to the correct answer of the item, (Pj) item difficulty index, (rjx) item discrimination index According to the analysis items written in bold (24. 25. ve 27) were removed from the test.

discrimination index value was calculated as 0.49. For the reliability analysis of the final version of the test, a total of 300 students were implemented, however the data of 270 students were included in the analysis. As a result of the analysis to calculate the difficulty index and discrimination index of the items, the items of 24, 25 and 27 were not at a sufficient value and were removed from the test. As a consequence of this application, the KR-20 reliability coefficient was found to be 0.92. According to Can (2014) since the KR-20 value in this test is greater than 0.60, it means that it is quite reliable in determining students' achievement levels.

## Discussion

Wherefore the limited number of achievement tests related to the sound and its properties unit after the publication of the 2018 curriculum, it was aimed to develop a valid and reliable achievement test that measures the acquisitions-concepts in the sound and its properties unit in sixth grades. The final version of the developed test consists of 27 questions in total by passing through preparation phases. According to Andersen et al. (2001) the question 24 in this test is in the factual knowledge-remember level; the questions 1-6-7-8-9-10-22-25-26-28-30 are in the conceptual knowledge understand level; the questions 3-4-5-11-14-16-18-20-21-27-29 are in the conceptual knowledge apply level; the questions 2-12-15-17-19-23 are in the conceptual knowledge- analyze level; the question 13 is in the conceptual knowledge-evaluate level.

Most of the questions in this developed test are at the conceptual knowledge level. As the questions include target behaviors such as interpreting information, drawing conclusions, determining causes and relationships, reordering in line with existing knowledge, comparing, finding similarities, comparing results, rearranging and calculating, they are of the conceptual knowledge-understand level (e.g., the questions 3-4-5- 11-14-16-18-20-21-27-29). Moreover, target behaviors such as directly remembering the knowledge, defining, selecting, sorting, naming, listing indicate that the question is in the factual knowledge-remember level (e.g., the questions of 1-6-7-8-9-10-22-25-26-28-30). Target behaviors such as asking for a cause-effect relationship, sorting by examining, establishing relationships, dividing knowledge, making inferences, and distinguishing indicate that it is in the conceptual knowledge-analyze level (e.g. questions 2-12-15-17-19-23).

The question 13, which is in the conceptual knowledge evaluate level, includes target behaviors such as combining data according to a certain relationship, creating and combining various possibilities, and determining knowledge (Cangıven, et al., 2017). As a result of the item analysis carried out in the development process of the achievement test, the difficulty index and discrimination index of each item in the test were calculated. While the difficulty index of the items varied between 0.34 and 0.49, the mean item difficulty value of the test was calculated as 0.41. When the item difficulty index approaches 1, it means that the test is weak, and when it approaches 0, it means that the test is more powerful (Turgut & Baykul, 2012).

The mean difficulty index of a test is expected to be around 0.50 (Gömlüksiz & Erkan, 2010). Accordingly, it can be stated that the test in this study is close to mean difficulty. In addition, as a result of the analysis, the discrimination index of each item in the test was calculated and although these values were between 0.45-0.56, the mean item discrimination of the test was found to be 0.49. The discrimination index takes values between +1 and -1. This value is used to show whether it distinguishes between students with higher levels of achievement in the test and students with lower levels of achievements. A value approaching +1 indicates a higher level of discrimination, while a value approaching 0 indicates a lower level of discrimination (Bayrakçeken, 2012).

Accordingly, looking at questions 24, 25 and 27, question 24, which had an item difficulty index of 0.23 and a discrimination index of 0.04, was removed from the test because it was both difficult and indiscriminate as a result of the item analysis. Similarly, question 25 was removed from the test because its item difficulty index was 0.27 and its item discrimination index was 0.08. Finally, question 27, which was a difficult item with a difficulty index of 0.26 and an item discrimination index of 0.06, was removed from the test. As a result, we can say that this test shows that it distinguishes students with high achievement level from students with low achievement level.

The KR20 reliability coefficient value of the developed PSCT was found to be 0.927. According to Altunışık et al. (2007) this value shows that the test has a reliable structure.

With refer to this, when looked at the questions 24, 25 and 27, the question 24 which had an item difficulty index of 0.23 and a discrimination index of 0.04, was removed from the test because it was both difficult and indiscriminate as a result of the item analysis. Similarly, the question 25 was removed from the test because its item difficulty index was 0.27 and its item discrimination index was 0.08. Finally, the question 27, which was a difficult item with a difficulty index of 0.26 and an item discrimination index of 0.06, was removed from the test. As a result, it can be stated that this test distinguishes students with higher achievement level from students with lower achievement level. The KR20 reliability coefficient value of the developed SPAT was found to be 0.927. According to Altunışık et al. (2007) this value shows that the test has a reliable structure.

The test developed in this study was finalized using statistical analyses such as reliability analysis and item analysis. When the literature is reviewed, it is mentioned that information about the construct validity of the test should be obtained through tetrachoric factor analysis, which is recommended to be used in recently developed tests (Nacaroğlu, et al., 2020; Keçeci, et al., 2019). As it is known, in the scoring of an achievement test, those who answer incorrectly are coded as 0 (zero) and those who answer correctly are coded as 1 (one). Therefore, typical factor analyses are performed with the SPSS program for statistical analysis in the coding from 1 to 5, which is frequently preferred in surveys. However, unlike the SPSS program, the construct validity of a test can be determined with the help of programs such as Mplus and FACTOR for scores coded as 0-1. 1,0 is used to determine the degree of relationship between two artificial and discontinuous variables with two categories (DokumacıSütçü & Oral, 2019).

## **Conclusion and Suggestions**

- In this study, tetrachoric factor analysis was not preferred because it was not in the researcher's area of expertise. For this reason, it is recommended that a tetrachoric factor analysis be conducted to examine the construct validity in future test development studies on this subject.
- In this study, although the required number of participants in the literature was reached with the convenience sampling method, it is recommended that studies with as large a sample size as possible be conducted in order to increase the reliability of the test and make more precise measurements.

- For the generalizability of the results, schools with different achievement levels should be selected and a parallel test should be developed to address large masses.
- For future research, open-ended questions that will develop higher level skills recommended to be asked in the tests to be developed for the same subject. Since multiple-choice questions were selected in this study, Bloom's Taxonomy is not sufficient to reveal higher level skills. Therefore, it is recommended to develop new tests that can measure both questions balanced with learning acquisitions and various skills.
- It is recommended to be conducted more than one pilot application of this test to determine the difficulty of the test in determining students' achievement in the subject of sound and its properties.
- It is also recommended to prepare questions with stronger distracters to determine students' misconceptions about this subject in future studies to be carried out in the development of the SPAT.
- As a result, it is suggested that this test can be applied as a readiness test for higher level students, as an end-of-unit assessment and as a test for reinforcement of unit topics. In addition, as a result of the statistical analysis for each item in the test, it is also recommended to develop new tests that will determine the level of students' misconceptions and conceptual understanding by looking at the strong distracters.

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APPENDIX I.

# Development of an Achievement Test for the 6<sup>th</sup> Grade Sound and its Properties Unit

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## Ortaokul Altıncı Sınıf Ses ve Özellikleri Başarı Testi

Sevgili öğrenciler;

Bu testin amacı, sizin fen bilimleri dersi ses ve özellikleri ünitesindeki konu-kazanımlar ile ilgili akademik başarılarınızın ne düzeyde olduğunu tespit etmektir. Cevaplarınız Fen Bilimleri dersi notlarınızı etkilemeyecek olup, bilimsel amaçlı olarak kullanılacaktır. Bu çalışmaya katıldığınız için ayrıca teşekkür ederim.

Adı:

Soyadı:

Sınıf:

1. Büşra, çalar saati çalıştırıp cam bir fanusun içine koymuştur. Daha sonra fanusun içinde havayı (hava boşaltma tulumbası) yardımıyla tamamen boşalmıştır. Sonrasında çalar saatten çıkan sesi tekrar dinlemek istemiştir.



(Havası boşaltılmış cam fanus)  
**İlk durum**



(İçinde hava olan cam fanus)  
**Son durum**

Büşra ilk durumda sesi duymazken son durumda çalar saatten çıkan sesi duyabilmiştir.

**Buna göre bu durumu aşağıdakilerden hangisi açıklar?**

- A) Cam fanus sesi iletmez.
  - B) Ses fanusta yansımıştır.
  - C) Çalar saatin sesi yeterince yüksek değildir.
  - D) Maddesel olmayan ortamda ses yayılmaz.
2. Bir öğrenci eline aldığı demir kaşığı, önce tahta masaya sonra sandalyenin metal ayağına sonrasında cam şişeye yavaşça vuruyor. Her seferinde aynı şiddetle vurmasına rağmen farklı sesler işitiyor. **Buna göre bu durumun nedeni aşağıdakilerden hangisinde doğru verilmiştir?**
    - A) Sesin maddesel olan ortamda yayılması
    - B) Gaz maddelerin sesi katılardan daha iyi iletmesi

- C) Farklı maddelerden üretilen seslerin farklı duyulması  
D) Sesin süratinin değişmesi

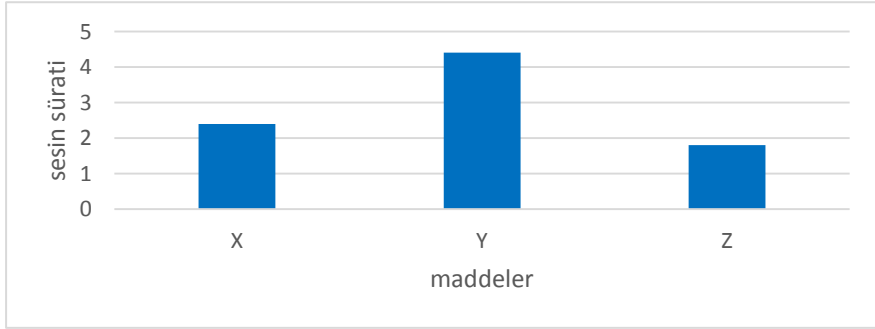
3.

1.	2. Madde	Sıcaklık(°C)	Sesin sürati (m/s)
3.	Hava	20	344
4.	Demir	20	5130
5.	Su	20	1440

Yukarıdaki tabloda aynı sıcaklıktaki farklı maddelere ait sesin süratleri karşılaştırılmıştır. **Buna göre; aşağıdakilerden hangisi söylenemez?**

- A) Sesin sürati en iyi gaz maddelerdedir.  
B) Sesin sürati en iyi katı maddelerdedir.  
C) Sesin sudaki sürati havadakinden fazladır.  
D) Sesin katı ortamındaki sürati sıvı ortamından fazladır.

4.



Yukarıda eşit sıcaklıklardaki x, y, z maddelerinde sesin yayılma süratleri verilmektedir.

**Buna göre maddenin yoğunlukları arasındaki ilişki nasıldır?**

- A)  $X > Y > Z$   
B)  $X > Z > Y$   
C)  $Z > X > Y$   
D)  $Y > X > Z$

5. Fen bilimleri öğretmeni olan Ömür, sesin bir enerji olduğunu gösteren günlük hayattaki olaylarla ilgili öğrencilerden bir poster hazırlamalarını istiyor. Buna göre;

- I. Alçaktan uçan bir uçağın bir okulun camlarını titretmesi  
II. Ses bombasının patlaması sırasında camların kırılması  
III. Ameliyatta böbrek taşlarının ses dalgaları ile kırılması

**Öğrenciler verilen bu örneklerden hangilerini posterlerinde kullanabilirler?**

- A) I ve III  
B) Yalnız II  
C) II ve III  
D) I, II ve III

6.



-Basketbol salonlarının parke zemin ile kaplı olması ve yankı olması



-Bir kaloriferin sıcak su borusunun çatlak olup olmadığını tespit edilmesi

Yukarıda verilen bu iki olayla ilgili sesin hangi özelliği anlatılmak istenmiştir?

- A) Sesin sürati
- B) Sesin soğurulması
- C) Sesin bir enerji türü olduğu
- D) Sesin yansımaları

7. “Akustik, sesin özelliklerini farklı ortamlardaki yayılımını, buldukları ortamlarla etkileşimini inceler. Bilim insanları, fizik mühendisleri, inşaat mühendisleri binaları tasarlamadan önce akustik ile ilgili araştırmalarda bulunur.” **Akustikle ilgili yukarıda verilen bilgiye göre aşağıda verilen mekânlardan hangisinde akustik biliminden yararlanır?**

- A) Otopark
- B) Sinema Salonu
- C) Alışveriş merkezi
- D) Hastane

8. Fen bilimleri öğretmeni Esra, öğrencisi Eda'ya ses ile ilgili bildiklerini söylemesini istiyor. **Buna göre Eda hangisini yanlış söylemiştir?**

- A) Sesin yayıldığı ortam değişirse sesi farklı işitiriz
- B) Ses boşlukta yayılmaz.
- C) Ses en iyi katı maddelerde yayılır.
- D) Farklı ses kaynaklarından aynı ses duyulur.

9. Şanlıurfa Ortaokulunda okuyan bir grup öğrenci teneffüs vaktinde top oynarken bir müddet sonra ders zilinin çaldığını duyarlar. Bir önceki ders ses ve özellikleri ünitesinde ses ile ilgili bilgileri öğrenen Zeliha arkadaşlarına bir soru yöneltir. “Sizce biz ders zilini nasıl duyabiliyoruz?”

**Tuncay:** Hoparlörden çıkan ses doğrusal olarak yayıldığı için duyabiliyoruz.

**Sıdıka:** Bence ses havada (gaz maddelerde) yayıldığı için duyabiliyoruz.

**İlya:** Sesin dalgalar halinde titreşim hareketi yaparak yayılması ve maddesel ortam olan hava ortamında yayılmasıyla duyarız.

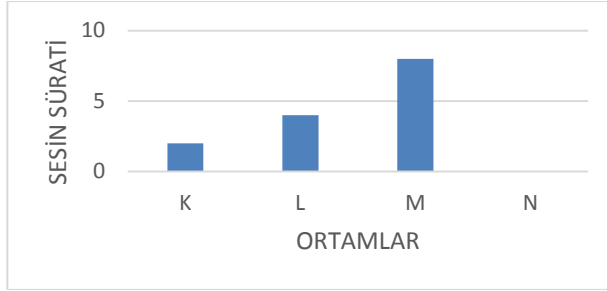
**Zeliha'nın yönelttiği soruya hangisi veya hangileri doğru cevaplamıştır?**

- A) Yalnız Sıdıka
- B) Sıdıka ve İlyâ
- C) Tuncay ve İlyâ
- D) Yalnız İlyâ

10. Sessizlik gerektiren bir ortamda (kütüphanede) olan Berat, sokaktaki iş makinelerin oluşturduğu sesin kulağına ulaşınca kadar sırasıyla iletiği ortamlar hangisinde doğru verilmiştir?

- A) Katı-Gaz-Sıvı
- B) Gaz-Katı-Gaz
- C) Katı-Katı-Gaz
- D) Gaz-Gaz-Katı

11.



Yukarıdaki grafikte sesin ortamlara göre sürat karşılaştırması verilmiştir. Buna göre bu ortamlardan hangisi maddesel olmayan (boşluk) ortam olabilir?

- A) K
- B) L
- C) M
- D) N

Deney	Sesin yayıldığı ortamlar	Sesin yayılmadığı ortamlar
1	Uzay boşluğu	Hava
2	İçi su dolu şişe	Havası alınmış cam fanus
3	Duvar	Uzay boşluğu
4	Havası alınmış cam fanus	Duvar

12.

Yukarıdaki tabloya bakıldığında sesin yayıldığı ve yayılmadığı bazı ortamlar verilmiştir. Buna göre numaralardan hangisi veya hangilerinde ortamlar yanlış eşleştirilmiştir?

- A) 1 ve 4
- B) Yalnız-3
- C) 1 ve 2
- D) Yalnız-4

13.



Ses kaynakları değiştiğinde duyulan sesin farklılaşması enstrümanın titreşen kısmının büyüklüğüne, yapıldığı maddenin cinsine, uzunluğuna, kalınlığına, gerginliğine vb. değişkenlere bağlıdır.

**Yukarıdaki bilgiye göre ses ile ilgili aşağıdaki yorumlardan hangisi yapılamaz?**

- A) Enstrümanlardaki titreşen kısmın büyüklüğü sesin farklı duyulmasına neden olur.
- B) Farklı sesler farklı kaynaklardan çıkar.
- C) Farklı cinsteki maddeler farklı sesler çıkarır.
- D) Farklı enstrümanlar havası alınmış bir ortamda farklı duyulur.

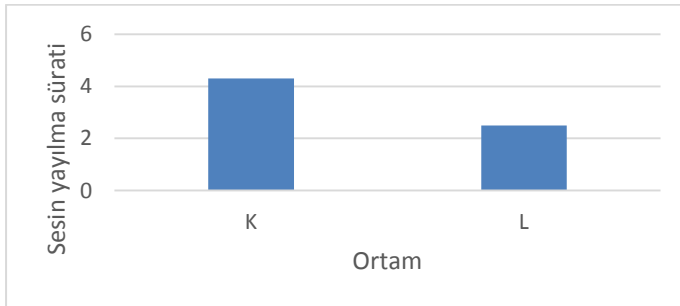
14.



**Aynı ortamlarda (sıcaklıkta) olan maddelerde sesin sürat karşılaştırması nasıl olur?**

- A) II > I > III
- B) I > II > III
- C) I > III > II
- D) II > III > I

15. Aşağıda sesin bazı ortamlardaki sürati ile ilgili bir grafik verilmiştir. Grafik incelendiğinde,

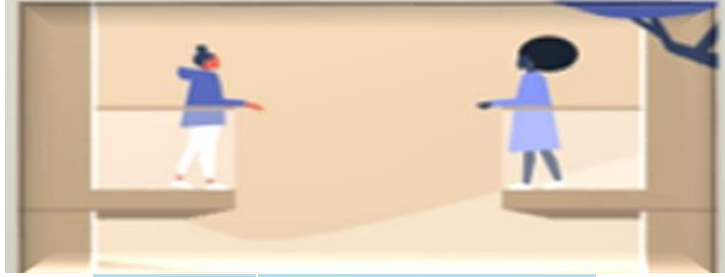


- I. Ortam sıcaklıkları eşitken K ortamını oluşturan tanecikler arasındaki mesafe, L ortamından azdır.
- II. Ortamın sıcaklıkları eşitken K ortamının yoğunluğu, L ortamından daha yoğundur.
- III. Ortam sıcaklıkları eşitken K ortamındaki titreşim hareketi, L ortamından fazladır.

**Yukarıdaki çıkarımlardan hangileri yapılabilir?**

- A) Yalnız I
- B) I ve II
- C) II ve III
- D) I, II ve III

16. Verilen görselde Özge, karşı komşuları olan Ayşe'ye sabah ve öğle vaktinde oyun oynamak için aynı şekilde seslenmektedir.



Vakit	Sesin ulaşma süresi
Sabah	1,8 s
Öğle	1.4 s

**Özge'nin sesinin Ayşe'ye ulaşma süreleri tablodaki gibi olduğuna göre aşağıdaki yorumlardan hangisi yapılamaz?**

- A) Özge'nin sesi öğle vakti sabah vaktine göre Ayşe'ye daha önce ulaşmıştır.
- B) Ses sabah vakti daha süratlidir.
- C) Hava öğle vaktinde daha sıcak olabilir.
- D) Havanın öğle vaktinde yoğunluğu daha fazla olabilir.

17. Serpil, gece vakti odasının penceresinden dışarıyı seyrederken şimşek çaktıktan bir süre sonra gök gürültüsünü duyabilmiştir.



**Bu olayın nedeni aşağıdakilerden hangisi olabilir?**

- A) Işık boşlukta yayılır.
- B) Sesin yayılma sürati ışıktan fazladır.
- C) Ses boşlukta yayılmaz.
- D) Işığın yayılma sürati sestten fazladır.

18. Nuriye okuldaki koro gösterisi için eline aldığı mikrofonla seslendireceği şarkıyı önce **banyoda** daha sonra **boş bir odada** sonrasında da **eşyalı bir odada** söylemiştir. **Şarkı söylerken her üç ortamda da sesini ses kayıt cihazına kaydetmiştir. Buna göre Nuriye'nin şarkı söylerken ki sesinin bu üç ortamda yayılması arasındaki ilişki nasıl olabilir?**



**Banyo  
(I)**

**Boş Oda  
(II)**

**Eşyalı Oda  
(III)**

- A) I>II>III  
B) I>III>II  
C) II>III>I  
D) III>I>II

19.



**Pamuk**

**Sünger**

**Strafor**

Yukarıda ses yalıtımını önlemek için kullanılan bazı malzemeler verilmiştir. **Ses yalıtımını önlemek için kullanılan bu malzemelerin en önemli sebebi ne olabilir?**

- A) Uzun ömürlü olması  
B) Sesi çok iyi iletmeleri  
C) Sesi iyi soğuramamaları  
D) Yumuşak ve gözenekli olmaları

20. Akustik, seslerin özelliklerini inceleyen bir bilim dalıdır.

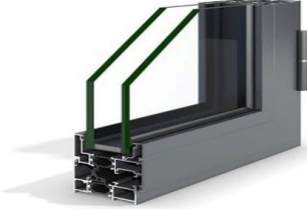
- Gürültünün azaltılması
- Sesin dengeli dağılımı
- Sesin kulağa hoş gelecek (estetik) şekilde yayılması
- Ses yalıtımı

Gibi konulara akustik düzenlemeler ile çözüm bulunmaktadır. **Aşağıda verilen örneklerden hangisi akustik düzenleme gerektirmez?**

- A) Cami  
B) Konferans salonu  
C) Sinema salonu  
D) Banyo

21. Mustafa elindeki ses kayıt cihazıyla sokakta ve evde şarkı söyleyip daha sonra dinlemek için kaydediyor. **Buna göre Mustafa'nın sesleri kaydetmesinin amacı aşağıdakilerden hangisi ile açıklanır?**
- A) Sesin soğurulmadığını ispatlamak
  - B) Sesin boşlukta yayılmadığını ispatlamak
  - C) Aynı ortamlardaki farklı kaynaklardan farklı ses çıktığını ispatlamak
  - D) Aynı ses kaynağından çıkan sesin farklı ortamlarda farklı duyulduğunu ispatlamak

22. "Çift cam teknolojisi: İki camın kenarlarına fitil koyup birbirine yapıştırılmasıyla elde edilen hem ısı hem ses iletimini oldukça azaltan bir teknolojidir."



Camlar birbirine yapıştırılırken camlar arasına Argon (Ar) gazı doldurularak işlem yapılır.

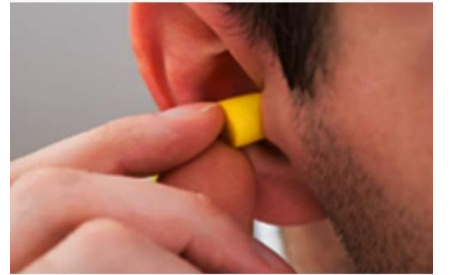
- Buna göre camların arasına Argon gazı doldurulmasının sebebi aşağıdakilerden hangisi ile açıklanabilir?**

- A) Gazların hem sesi hem ısıyı daha iyi iletmesi
- B) Gazların ses iletimini katı ve sıvılara göre daha az iletilmesi
- C) Sıvıların ses iletiminin gazlardan daha iyi olması
- D) Gazların sesi sıvılara göre daha fazla yansıtması

23.

Çalıştığı iş yerinde yüksek ses şiddetine maruz kalan Mehmet Bey yüksek sesin baş ağrısı yapması sebebiyle görseldeki gibi kulak tıkacı takmıştır. Buna göre Mehmet Bey'in kullandığı kulak tıkacı ile ilgili;

- I. Sesi yansıtmalıdır
- II. Sesi soğurmalıdır
- III. Dış ortamlardaki sesleri daha iyi kulağına aktarmalıdır
- IV. Yumuşak ve gözenekli yapıda olmalıdır



**Yorumlarından hangileri yapılabilir?**

- A) Yalnız I
- B) II ve IV
- C) I, II ve III
- D) I ve III

24. **Aşağıdaki ortamların hangisinde sesin yayılma hızı en yavaştır?**

- A) Hava
- B) Zeytinyağı
- C) Bakır
- D) Tahta

25. Ses dalgasının çarptığı ortamda enerjisini kaybetmesine ve bunun sonucunda yayılamamasına soğurulma denir. Yumuşak ve gözenekli malzemeler, sert ve pürüzsüz malzemelere göre sesi daha iyi soğurur. **Buna göre sesi soğurma amaçlı,**

- I. Sünger
- II. Tahta
- III. Demir

**Malzemelerinden hangileri kullanılabilir?**

- A) Yalnız I                      B) I ve II                      C) II ve III                      D) I, II ve III

26.

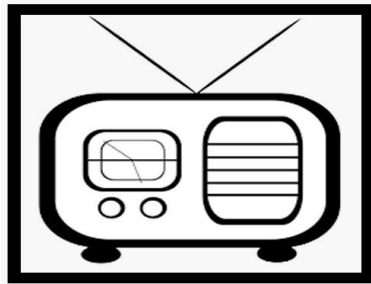


Şekildeki tokmakla defe vurulduğunda, diğer defin arkasındaki asılı olan iki küçük topun hareket edildiği görülüyor.

**Yapılan bu gözleme göre aşağıdakilerden hangisine ulaşılabilir?**

- A) Ses bir enerji türüdür.
- B) Ses dalgalar halinde yayılır.
- C) Ses, gazlarda çok hızlı yayılır.
- D) Ses boşlukta yayılamaz.

27.



Kadriye, yukarıdaki gibi radyo ve kutu kullanarak bir düzenek hazırlıyor. Kadriye kutuyu **aşağıdaki malzemelerin hangisiyle kaplarsa radyonun sesini diğerlerine göre daha fazla duyar?**

- A) Kâğıt                      B) Pamuk                      C) Demir                      D) Tahta