Research Insights
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COGNITIVE-DIDACTIC MODEL WHEN GENERATING TESTING ITEMS ON THE TOPIC OF "MECHANICAL OSCILLATION"

Georgi Totkov, Zhelyazka Raikova,
Marieta Atanasova
Plovdiv University "Paisii Hilendarski"

Abstract. In this article is presented a cognitive-didactic model based on which can be generated testing items, which assess the achievements at school students in the physics section „Mechanical oscillation". The model is based on the extended Bloom's Taxonomy and can be used in conventional physics education at Secondary school as well as in e-learning. An example test, which was constructed by applying the presented model, has been offered.

Keywords: cognitive-didactic model; testing items; Bloom's Taxonomy; "Mechanical oscillation" test

1. Introduction

Pedagogical experience and intuitive judgment of the teachers lay in the basics of constructing testing items in contemporary assessment. In order to check results and obtain an assessment in an objective way, testing items should be generated **(TI)**. They are to be created on the base of the same methodology and will also test all the cognitive levels of knowledge in the students being examined. The generated **TI** should assess precisely and clearly the achievements. Thus, when being created it is a good idea to follow a number of methodic recommendations. The testing items should be (Sokolova-Raykova, 2011; Bizhkov, 1996):

– As simplifies and short as possible in order to make reading and understanding easy.

– Constructed so that correspond to an important chapter of the content studied.

– Independent from one another. Solving one task should not depend on solving another one.

– In accordance with the length and level of difficulty of the testing task, and correspond to the age characteristics of the tested students.

– With dominating incorrect answers because they have a higher discriminative value than the correct ones.

– Avoided answers like “all of the above” or “none of the above”.
– Contain only that information which is necessary to solve the task correctly.
– Provide non-ambiguous answers. Ambiguity should be avoided.

The methodic recommendations suggested above are sufficient enough to generate testing items of all kind i.e. with alternative answers, matching answers, replacement **TI**, association **TI**, open-answer **TI** and others. They could all be applied in computer as well as conventional testing in a different subject area and more specifically in our case – “Mechanical oscillation” – physics of 9th grade. So far, experience has shown that the tests are created based on the subjective preferences of the teachers in the educational process (Stoimenova, 2000).

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This, however, leads to non-objective assessment of the knowledge, skills and habits, as well as decreases the efficiency and liability of the results gained. A possible solution to this problem is offering a big number of sample testing items, which will minimize subjectivity and will accelerate the process of creating precise and correct **TI** according to the learning content. Generating a model of that kind is related to dividing the testing items into categories according to the cognitive levels of the learners’ knowledge, namely the extended Bloom’s Taxonomy, which consists of – remembering, understanding, application, analysis, assessment and creating, as well as classifying them into a second semantic dimention referring to *facts*, *concepts* and *procedures* (Bizhkov, 1996; Anderson, Krathwohl, 2002).

2. Cognitive-didactic model of testing items in„Mechanical oscillations” – physics in 9th grade

In order to cover all the knowledge levels when formal or informal precise assessment, it is necessary to prioritize the objectives. A good idea, on the one hand, is to divide the **TI** into two basic levels. The first refers to the cognitive levels of the extended Bloom’s Taxonomy (mentioned above). On the other hand, the **TI** are to be classified in accordance with their semantic sublevels and define what exactly the specific level of knowledge refers to i.e. the type of knowledge. Bearing in mind that model, each **TI** is positioned according to the characteristics it describes. Thus, the teacher can easily find the wanted testing item when checking specific knowledge (Stoimenova, 2000; Todorova, 1998).

By following the positions offered, up until the present moment has been generated two similar models. The first one is in the field of physics – 86 samples **TI**, and a second one in foreign language education – more than 100 **TI** in English language.

The model is offered to generate a number of samples TI in the physics area with a subsection of "Mechanical oscillation" for 9th grade.

2.1. Remembering

Facts

1. *Give a definition of mechanical oscillation (harmonic oscillation, damped oscillation, forced oscillation, resonance, mathematical pendulum, spring pendulum).*

2. *Which of the following examples is **NOT** related to mechanical oscillation??*

a) oscillation of a tuning fork;
b) a guitar string;
c) motion of a car tire;
d) motion of a pendulum.

3. *Which of the following figures describes mechanical oscillation?*

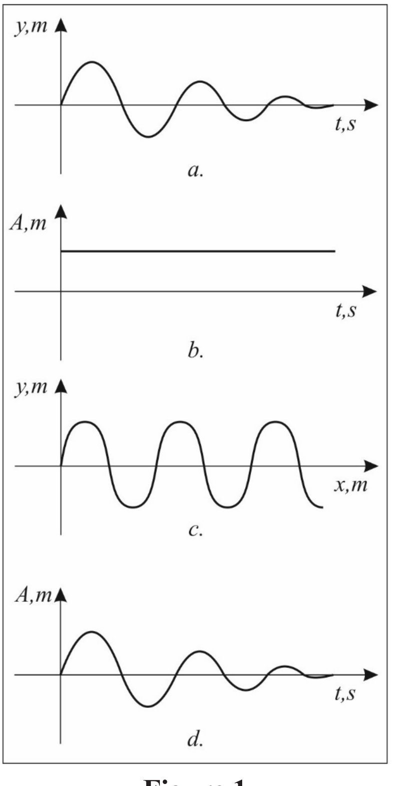

Figure 1

4. *Which of the following examples are **NOT** forced oscillations?*
   a) oscillation of a bridge construction with cars passing by;
   b) oscillation of the tree leaves;
   c) movement of the needle of a sewing machine;
   d) oscillation of a guitar strings.
5. What is the amplitude dependent on when a mechanical oscillation happens?
6. *Which of the following mechanical oscillations are **NOT** damped oscillations?*
   a) pendulum swinging;
   b) heart beating;
   c) oscillation of a tuning fork when being hit;
   d) shaking water in a pot.

7. *What is the velocity of the train when resonance occurs if the period of its own oscillations of a railway wagon is 1,25s, the length of a rail is 25 m. and where the rails connect with each other, the wagon suffers vertical turbulence which cause forced oscillation?*

a) $36\ \frac{\text{km}}{\text{h}}$; b) $72\frac{\text{km}}{\text{h}}$; c) $76\frac{\text{km}}{\text{h}}$; d) $84\frac{\text{km}}{\text{h}}$.

Concepts

8. The *dumping of a mechanical oscillation always brings to:*
   a) resonance;
   b) decrease in the amplitude;
   c) keeping the energy;
   d) increase in the amplitude.

9. *If we increase the length of a mathematical pendulum four times, how does the period change?*
   a) it is increased twice;
   b) it is decreased twice;
   c) it is increased four times;
   d) it is decreased four times.

10. *Which of the following кои values is the oscillation frequency of a spring pendulum dependent on?*
    a) the volume of the pendulum;
    b)the length of the spring;
    c) the elasticity coefficient of the spring pendulum;
    d) the acceleration of gravity.

Procedures

11. *In which of the following case, there is harmonic oscillation?*
    a) string oscillation;
    b) spring pendulum;
    c) tree leaves;
    d) shaking water in a pot.

12. *If mathematical pendulum has a length of 10 м, define its oscillation frequency? (g= 10 m/s).*

a) 0,16 Hz; b) 0,628 Hz; c) 1 Hz; d) 1,16 Hz.

2.2. Understanding

Facts

13. *Which of the following phenomena is* ***NOT*** *a mechanical oscillation?*

a) radio broadcasting;
b) oscillation of bee wings;
c) oscillation of the building particles of a substance;
d) blinking of an electrical lamp.

14. *Which of the following formulae shows the relation between period and frequency?*

a) $v = 2\pi T$; b) $v = \frac{T}{2\pi}$;

c) $T = \frac{v}{2\pi}$; d) $T = \frac{1}{v}$.

Concepts

15. *How is the value of the amplitude changed in dumped oscillation and why?*

Procedures

16. *Calculate the values of the period of a tuning fork oscillation, which oscillates with a frequency of 200 Hz.*

a) $T = 0,005$ s;

b) $T = 0,05$ s;

c) $T = 0,02$ s;

d) $T = 2$ s.

2.3. Analysis

Facts

17. *Describe the condition in which the phenomenon resonance occurs?*

Concepts

18. *What are the amplitude and the period of the oscillation shown in the graphics?*

a) T = 0,8 s; A = 3 m;
b) T = 0,6 s; A = 2 m;
c) T = 0,4 s; A = 2 m;
d) T = 1 s; A = 3 m.

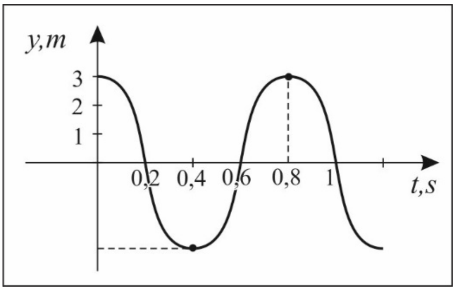

Figure 2

Procedures

19. *A steel ball is hanging from a thread with the length of "l", and on a thread with same length is hanging a ping-pong ball. Compare the oscillation periods of the two pendulums.*

2.4. Assessment

Facts

20. *Which of the following formulae describes the frequency of a spring pendulum?*

a) $v = 2\pi T$; b) $v = \frac{T}{2\pi}$;

c) $v = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$; d) $v = 2\pi\sqrt{\frac{m}{k}}$.

Concepts

21. *What is the difference of the two harmonic oscillations whose graphics are shown below?*

a) amplitude; b) period and amplitude;
c) period; d) period and frequency.

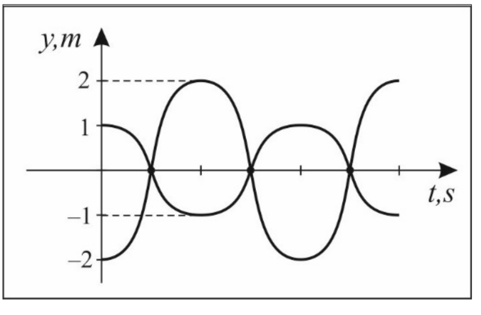

Figure 3

Procedures

22. *Describe a manner of experimental measurement of the string pendulum period?*

2.5. Creating

Facts

23. *What conditions can force oscillations to be observed?*
24. *Will a forced oscillation be observed if none external forces are applied?*

Concepts

25. *Make a graphic of the resonance phenomenon.*
26. *Make a table where the positive and negative of the resonance phenomenon should be signified.*

Procedures

27. *For an experimentally defined period of a mathematical pendulum, make a table where the measured values should be inserted.*

2.6. Application

Facts

28. *Give at least two examples of the resonance phenomenon application.*

Concepts

29. *Calculate the number of oscillations* **n** *which a mathematical pendulum does, with the length of l= 4.9 m, for the time of 5 min.*

a) n = 68; b) n = 86; c) n = 9; d) n = 60.

Procedures

30. *Describe a dumped and forced oscillation in one coordinate system.*

3. Conclusion

One of the foremost problems of nowadays testology is how to create one of a kind methodology to generate testing items so that subjective factor can be avoided and cover more precisely and clearly the learning contents when knowledge, skills and habits are being tested and assessed.

Offering a cognitive-didactic model, considerably decreases the time of generating **TI** and increases the objectivity of the final results. It can be applied in conventional physics learning as well as in e-learning. A hierarchical model of sample TI according to the extended Bloom's Taxonomy has been offered, which defines physics knowledge into three semantic sublevels of the physics subdivision "Mechanic oscillation" and covers the specific concepts for this area of knowledge.

This approach not only makes the work of the teacher-tester easier, but also the testing process gives the opportunity to personalize it to the necessary cognitive level of the specific learner.

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✉ **Prof. Dr. Georgi Totkov**
Dr. Zhelyazka Raikova, Assoc. Prof.
Ms. Marieta Atanasova, Assist. Prof.
Plovdiv University "Paisii Hilendarski"
Plovdiv, Bulgaria
E-mail: totkov@uni-plovdiv.bg
E-mail: janeraikova@gmail.com
E-mail: marieta.atanasova@gmail.com