ÉRETTSÉGI VIZSGA • 2025. május 20.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

JAVÍTÁSI-ÉRTÉKELÉSI
ÚTMUTATÓ

OKTATÁSI HIVATAL

The examination papers should be evaluated and graded clearly, according to the instructions of the evaluation guide. Markings should be in red ink, using the conventional notations.

PART ONE

For the multiple choice questions, the two points may only be awarded for the correct answer given in the evaluation guide. Enter the score (0 or 2) in the gray rectangle next to the question as well as the table for total scores at the end of the exam paper.

PART TWO

The student should explicate the answers to the questions in a continuous text in whole sentences, so sketchy outlines are not to be evaluated. The only exception is any explanatory text or label of a drawing. Scores for facts or information mentioned in the evaluation guide may only be awarded if the student explains it in proper context. Partial scores must be written on the margin with indication as to which item of the evaluation guide is the basis of awarding it. The evaluated statement in the text must be ticked. The scores must also be entered in the table following the questions of the second part.

PART THREE

Principles for dividing allocated scores:

- The sentences printed in italics in the evaluation guide define the steps necessary for the solution. The scores indicated here may and should be awarded if the action or operation described by the text in italics can be clearly identified in the work of the student and is basically correct and complete.
- The „expected solution" is not necessarily complete; its purpose is to indicate the nature and extent of the expected solution, and the depth of detail required from the student. Comments in brackets that follow provide further guidance on the evaluation of possible errors, differences or incomplete answers.

Principles for evaluating alternative trains of thought:

- Correct answers that differ from the reasoning of the one (ones) given in the evaluation guide are also acceptable. The lines in italics provide guidance in allocating scores, e.g. what part of the full score may be awarded for a correct interpretation of the question, for stating relationships, for calculations, etc.
- Should the student combine some steps, or carry on calculations algebraically, he/she may skip the calculation of intermediate results shown in the evaluation guide. If these intermediate results are not being explicitly asked for in the original problem, the scores indicated for them should be awarded if the reasoning is otherwise correct. The purpose of indicating scores for intermediate results is to make the evaluation of incomplete solutions easier.

Principles for the avoidance of multiple deductions:

- For errors that do not affect the correctness of reasoning (miscalculations, clerical errors, conversion errors, etc.) deduce points only once.
- Should the student display multiple attempts at solving the problem, and does not indicate clearly which one of those he/she wants evaluated, the last one should be considered (i.e. the one at the bottom of the page if there is nothing to indicate otherwise). If the solution contains a mixture of two different trains of thought, the elements of only one of them should be evaluated: that one which is more favorable for the student.
- If an action or operation defined in the evaluation guide is completed, but the results are incorrect due to errors committed previously, full points allocated for this action are to be awarded. If the action can be broken down into steps, partial scores are indicated beside each line of the expected solution.

Principles regarding the use of units:

- The lack of units during calculation should not be considered a mistake – unless it causes an error. However, the results asked for in the problem are acceptable only with proper units.
- Graphs, diagrams and notations are acceptable only if they are unambiguous (it must be clear what the graphs show, markings should be in place, unconventional notations must be explained, etc.). The lack of units on the axis labels of graphs should not be considered a mistake however, if the units are otherwise obvious (e.g. quantities given in a table must be plotted, all with the same units).

After evaluation, the appropriate scores should be entered in the summarizing tables.

PART ONE

1. D
2. B
3. B
4. C
5. A
6. A
7. C
8. C
9. A
10. D
11. A
12. B
13. B
14. A
15. D

2 points for each correct answer.

Total: 30 points

PART TWO

Each of the scores may be divided for all three topics.

1. Free diving

a) Listing the forces that act upon an object submerged in a liquid and defining the condition for the object to float:

3 points

Gravitational force G (1 point) and the hydro-static buoyancy F_b (1 point).
An object floats on top of the water (rises to the surface) if $G < F_b$ (1 point).

(The condition for floating may also be defined using densities.)

b) The analysis of hydro-static pressure:

2 points

Pressure is proportional to the density of the liquid (1 point) and to the depth (1 point).
(A formula can also be accepted provided that the student explicitly names the physical quantities in the formula.)

c) Discussing the volume change of liquids and gases:

2 points

The volume of a gas decreases (1 point) if the pressure increases, the volume of a liquid changes much less (1 point). (Does not change is also acceptable).

d) Analysis of the variation of the forces that act on the athlete:

4 points

The gravitational force is constant (1 point) during the dive, the buoyancy force decreases as the athlete dives deeper (1 point). This is because pressure increases with the depth (1 point) and so does the pressure of the air in the lung, therefore the lung's volume decreases or the mean density of the athlete increases (1 point).

e) Analysis and correcting the part underlined in the text:

3 points

The underlined text is not correct (1 point).
Instead of "I am heavier than the water surrounding my body" it is more correct to say "I am heavier than the water my body displaces" (1 point).
Instead of "buoyancy ceases", it is more correct to say "buoyancy becomes smaller than the gravitational force" (1 point).

f) Discussion of when the athlete must swim by paddling herself:

2 points

During the descent, the athlete must swim at small depths because there $F_b > G$ (1 point).
During the ascent, the athlete must swim at large depths because there $F_b < G$ (1 point).

g) Determining the volume in question:

2 points

$$V_2 = V_1 \cdot \frac{p_1}{p_2} = 5 \cdot \frac{10^5}{(1+8.6)\cdot 10^5} \approx 0.5\ \text{l}$$ (formula + calculation, 1 + 1 points)

Total **18 points**

2. The nuclear clock

a) Reviewing Bohr's model of the atom and the explanation of energy emission and absorption:

8 points

In the description of the model, the student must state that due to the electrostatic interaction, electrons (1 point) orbit around the atomic nucleus (1 point) on discrete orbits which also have discrete (well defined) energies (1 point).

Inner orbits have lower energies (1 point), than do outer ones. The jump of an electron from an outer orbit to an inner one (1 point) is accompanied by the release of energy (or the emission of a photon) (1 point).

The transition of an electron from an inner orbit to an outer one (1 point) requires energy absorption (1 point) by the atom.

(Any other correct statement about Bohr's atomic model must also be accepted. (e.g. the model is valid only for the hydrogen atom. The orbits are circular. The angular momentum of the electrons on the orbits is quantized, etc.) Each correct statement is worth 1 point, a maximum of 8 points may be given.)

b) Determining the energy difference of the two electron orbits used for the atomic clock:

3 points

$\Delta E = \varepsilon = h \cdot f = 6.63 \cdot 10^{-34} \cdot 9192631770 \approx 6 \cdot 10^{-24}\,\mathrm{J}$

(formula + substitution of data + calculation, 1 + 1 + 1 points)

c) Naming the frequency range:

1 point

It is in the microwave-range as it can be excited using microwave radiation.

d) Naming the nucleons and identifying their location in the atom:

2 points

Proton and neutron (1 point), they are found in the atomic nucleus (1 point).

e) Naming the radiation emitted by excited nucleons:

2 points

Gamma radiation.

f) Naming the advantage of a nuclear clock and the difficulty in realizing it:

2 points

Because the energy levels are more stable, the accuracy of the clock is higher (1 point).
Because of the larger energy difference, nucleons are more difficult to excite (1 point).

Total **18 points**

3. Collisions

a) *Defining the concept of momentum and naming its physical unit:*

1 + 1 points

b) *Defining the concept of a closed system, explanation of the principle of momentum conservation:*

1 + 1 points

c) *Expressing Newton's second law using the concept of momentum:*

2 points

d) *Explaining the connection between Newton's third law and the principle of momentum conservation:*

2 points

e) *Reviewing perfectly inelastic collisions:*

1 points

f) *Applying the principle of momentum conservation for a perfectly inelastic collision, calculating the final velocity:*

1 + 1 points

g) *Reviewing elastic collisions:*

1 point

h) *Applying the principle of momentum conservation and the conservation of kinetic energy for elastic collisions, explaining how the final velocities can be calculated:*

1 + 1 points

(Writing down the principles of momentum conservation and energy conservation: 1 point, writing down the two final velocities: 1 point)

i) *Describing the elastic collision in the center-of-mass reference frame:*

2 + 2 points

(Identifying the velocity of the center-of-mass reference frame as the final velocity of the perfectly inelastic collision: 2 points. Realizing that in this reference frame, the colliding bodies rebound with the same speed as their speed of arrival was before the collision: 2 points.)

Total **18 points**

Evaluation of the style of the presentation based on the exam description, for all three topics:

Lingual correctness: ***0–1–2 points***

- The text contains accurate, comprehensible, well structured sentences;
- there are no errors in the spelling of technical terms, names and notations.

The text as a whole: ***0–1–2–3 points***

- The review as a whole is coherent and unified;
- individual parts, subtopics relate to each other along a clear, comprehensible train of thought.

No points may be awarded for the style of presentation if the review is no more than 100 words in length.

If the student's choice of topic is ambiguous, the content of the last one written down should be evaluated.

PART THREE

When evaluating the calculations, care must be taken to deduce points for errors that do not affect the correctness of reasoning (miscalculations, clerical errors) only once. If the student uses a previously miscalculated result in further steps of the solution correctly, full points are to be awarded for these steps. Thus it may be possible that full points are due at certain steps for solutions that differ from the values given in the evaluation guide.

Problem 1

Data: $v_b = 5$ m/s, $d = 64$ cm, $r = 20$ cm

a) The correct geometric interpretation of the problem:

2 points

The cat's eye will move fastest relative to the ground, when its v_c' velocity relative to the axle is parallel with the velocity of the bike. (At the highest point of its trajectory.)

Formulating the velocity of the cat's eye relative to the axle and calculating the maximum speed relative to the ground:

4 points
(may be divided)

Because the tangential velocity (relative to the axle) of any point on the wheel's circumference is equal to the translation speed of the bike:

$$v_c = v_b + v_c' = v_b + \frac{r}{d/2} \cdot v_b = 5 + 3.125 = 8.125 \ \frac{\text{m}}{\text{s}}$$

(formula + substitution of data + calculation, 2 + 1 + 1 points)

b) The correct geometric interpretation of the problem:

1 point

When the line connecting the axle and the cat's eye is horizontal, the velocity of the cat's eye relative to the axle is vertical.

Determining the magnitude of the velocity relative to the ground:

3 points
(may be divided)

$$v_c = \sqrt{v_b^2 + \left(v_c'\right)^2} = \sqrt{5^2 + 3.125^2} = 5.9 \frac{\text{m}}{\text{s}}$$

(formula + substitution of data + calculation, 1 + 1 + 1 points)

Total: 10 points

Problem 2

Data: $I_1 = I_3 = 0.16$ A, $U_1 = 16$ V, $P_2 = 5.12$ W.

a) Determining the resistance values:

7 points
(may be divided)

$R_1 = \frac{U_1}{I_1} = 100\ \Omega$ (formula + calculation, 1 + 1 points).

As the current on resistors connected in series is equal, $I_2 = I_1 = 0.16$ A (1 point), so

$R_2 = \frac{P_2}{I_2^{\,2}} = 200\ \Omega$ (formula + calculation, 1 + 1 points).

As the currents in the two parallel branches are equal, so are their resistances, so:
$R_3 = R_1 + R_2 = 300\ \Omega$ (formula + calculation, 1 + 1 points).

b) Determining the voltage of the battery:

2 points
(may be divided)

$U_t = R_3 \cdot I_3 = 300 \cdot 0.16 = 48$ V (formula + calculation, 1 + 1 points)

c) Determining the net resistance:

3 points
(may be divided)

$$\frac{1}{R_e} = \frac{1}{R_1 + R_2} + \frac{1}{R_3} = \frac{2}{300} \Rightarrow R_e = 150\ \Omega$$

(formula + calculation, 2 + 1 points)

Total: 12 points

Problem 3

Data: $m_w = 10$ kg, $t_1 = t_2 = 50$ min, $L = 334$ kJ/kg, $c = 4.2$ kJ/(kg°C), $\Delta T = 10$ °C.

a) Realizing that, due to the constant power, the heat transferred during the first and second time intervals are equal:

2 points

$Q_1 = Q_2$

Writing down the formula that expresses the equality of the heat transfers and determining the initial mass of the ice.

6 points
(may be divided)

$m_{ice} \cdot L = (m_{ice} + m_w) \cdot c \cdot \Delta T$ (the correct formulation of the two sides of the equation, 1 + 1 points)
from which:
$m_{ice} = \frac{m_w \cdot c \cdot \Delta T}{L - c \cdot \Delta T} = \frac{10 \cdot 4.2 \cdot 10}{334 - 4.2 \cdot 10} = 1.44$ kg
(rearrangement + substitution of data + calculation, 2 + 1 + 1 point)

b) Determining the power of the heating:

4 points
(may be divided)

$P = \frac{Q_1}{t_1} = \frac{m_{ice} \cdot L}{t_1} = \frac{1.44 \cdot 334}{3000} = 160$ W
(formula + substitution of data + calculation, 2 + 1 + 1 points)

Total: 12 points

Problem 4

Data: $n_{\text{petrol}} = 1.4$, $n_{\text{glass}} = 1.5$

a) Analysis of path taken by a light ray incident parallel with the axis in the first case:

6 points
(may be divided)

The light ray propagating parallel with the long axis reaches one of the facets of the wedge-shaped end of the rod at a 45 ° angle of incidence (1 point).
The critical angle at the glass-petrol vapor (air) interface is:

$\sin \alpha_c = \frac{1}{n_{glass}} \rightarrow \alpha_c = 42°$ (formula + calculation, 1 + 1 points)

Because $\alpha > \alpha_c$, the light-ray undergoes total internal reflection (1 point).
It then reaches the opposite facet of the wedge also at a 45 ° angle of incidence (1 point), so it is reflected again and goes back parallel with the axis (1 point) to the outside end of the rod.
(Instead of the description, a figure depicting the path of the light-ray is also acceptable, provided the angles of incidence are unambiguously defined.)

b) Analysis of path taken by a light ray incident parallel with the axis in the second case:

3 points
(may be divided)

If the end of the rod is inside the petrol, the critical angle for total reflection is:

$\sin \alpha_c' = \frac{n_{petrol}}{n_{\text{glass}}} \rightarrow \alpha_c' = 69°$ (formula + calculation, 1 + 1 points)

Therefore the light-ray will exit the rod at the end (1 point).

c) Naming the difference seen at the upper end of the glass rod:

2 points
(may be divided)

If the light-ray is reflected and returns, the end of the glass rod appears bright (1 point), in the opposite case it appears dark (1 point).

d) Explaining how the fuel level gauge works:

2 points
(may be divided)

The higher the level of petrol is in the fuel tank, the more of the glass rods with decreasing lengths reach into the petrol (1 point), therefore the more of the rod ends will appear dark (1 point) on the fuel tank cap.

Total: 13 points

The origin of the sources for the problem sheet (pictures, drawings, data):

I/2.https://educacao.uol.com.br/disciplinas/fisica/ondas--a-interferencia-ondulatoria.htm
II/1. The text of the problem was obtained by modifying the source text (shortening and simplifying the grammar), while keeping the integrity of the source intact.
https://24.hu/sport/2021/01/17/korok-fatima-szabadtudos-merules-magyar-csucs-uszas/
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