ÉRETTSÉGI VIZSGA • 2018. május 22.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

JAVÍTÁSI-ÉRTÉKELÉSI
ÚTMUTATÓ

EMBERI ERŐFORRÁSOK MINISZTÉRIUMA

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 can 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).

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

PART ONE

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

Award ***2 points*** for each correct answer.

Total 30 points

PART TWO

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

1. Nuclear waste

Naming and characterizing the three types of radioactive decay:

1 + 1 + 1 points

α – He nucleus
β – electron
γ – electromagnetic radiation
The expression "α-particle" etc. is not sufficient.

Explaining the concept of half-life:

2 points

Defining the concept of activity, and explaining the meaning of the unit kBq/kg:

1 + 2 points

Explaining why the activity and the lifetime of the waste are important:

4 points

Large activity →greater health risk (2 points).
Long lifetime →secure storage is required for a longer time (2 points).

Naming and explaining the first step in processing high-level waste:

3 points

Because it generates a considerable amount of heat (1 point), it must be cooled (1 point) for a while, it must be stored in a spent fuel pool (1 point).

Determining the time required for the activity of the waste to reduce to the low-level category:

3 points

Because the initial activity of the fuel, $7.8 \cdot 10^6$ kBq/kg, is about 16 times larger (1 point) than the upper limit of the low-level category, the time required for decay is four times the half-life (1 point), because $2^4 = 16$. Thus the required time is about 844000 years (1 point).

Total 18 points

2. Polar bear

Naming and characterizing the three forms of heat exchange:

2 + 2 + 2 points

Determining the external temperature of the polar bear's fur; explaining its significance from the point of view of tracking:

1 + 1 points

The external temperature of the bear's fur is the same as the ambient temperature (1 point), so it cannot be tracked with an infrared camera (1 point).

Analyzing the significance of retaining air:

4 points

Air is a good insulator (1 point), on the other hand water conducts heat well (1 point).
Therefore, the fur is a much better insulator if the space between the hairs is filled with air (1 point) instead of water.
Besides, fur filled with air helps remaining on the surface of water (1 point).

Explaining the reasons for retaining air:

2 points

The fur of the bear is very dense (1 point) and covered with water repelling tallow (1 point).

Naming the reason for agile movement and quick changes of direction:

1 point

The leather cushions on the bear's paw do not slip on ice.

Determining the average speed of the bear:

3 points

$$v_{av} = \frac{s}{t_{run} + t_{swim}} = \frac{s}{\frac{s}{2 \cdot v_{run}} + \frac{s}{2 \cdot v_{swim}}}$$ (1 point), i.e.

$$v_{av} = \frac{2 \cdot v_{run} \cdot v_{swim}}{v_{run} + v_{swim}} = 16\ \frac{\text{km}}{\text{h}}$$ (transformation + calculation, 1 + 1 point).

Total 18 points

3. The laws of Newton

Reviewing the law of inertia:

1 point

Explanation using an everyday example:

1 point

Inertial frames and Newton's laws:

1 + 1 points

A <u>reference frame</u> with respect to which <u>the law of inertia is valid</u>.

Reviewing the second law of Newton using the acceleration of bodies:

1 point

An everyday example for the law:

1 point

Introducing the concept of momentum:

1 point

Writing Newton's second law using the concept of momentum:

2 points

Reviewing the law of action-reaction:

1 point

An everyday example for the law:

1 point

Explaining the law of momentum-conservation:

1+1 points

A <u>closed system</u> where the total <u>momentum is conserved</u>.

Verifying the law of momentum-conservation using Newton's third law:

4 points

Introducing the theorem regarding the independence of forces:

1 point

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: A = 150 cm^2, h = 20 cm, m = 0.5 kg, M = 7.9 kg, $g = 9.8\ \frac{\text{m}}{\text{s}^2}$, $\rho_{water} = 1\ \frac{\text{kg}}{\text{l}}$,

$\rho_{iron} = 7.9\ \frac{\text{kg}}{\text{l}}$.

Recognizing that the force shown by the weigh scale is the sum of the weights of the container and the water and additionally the hydro-static buoyancy force acting on the piece of iron:

3 points

$F_1 = G_{water} + G_{cont} + F_{buoy}$

(This recognition need not be written down explicitly. If the student evidently performs the calculations accordingly, the three points are to be awarded.)

Determining the force shown on the weigh scale:

6 points
(may be divided)

The weight of the water: $G_{water} = \rho_{water} \cdot A \cdot h \cdot g = 3\ \text{kg} \cdot g\ =\ 29.4\ \text{N}$
(formula + calculation, 1 + 1 points)

The buoyancy force acting on the piece of iron: $F_{buoy} = \frac{M}{\rho_{iron}} \rho_{water} \cdot g =\ 9.8\ \text{N}$

(formula + calculation, 2 + 1 points)

The value shown on the scale is thus: F_1 = 29.4 N + 4.9 N + 9.8 N = 44.1 N (1 point).

Determining the force shown on the spring scale:

3 points
(may be divided)

$F_2 = G_{iron} - F_{buoy}$ (2 points),

i.e. F_2 = 77.4 N – 9.8 N = 67.6 N (1 point).

Total: 12 points

Problem 2

Data: $P = 40$ W, $U_1 = 110$ V, $U_2 = 230$ V.

Determining the resistances of the resistor wires:

4 points
(may be divided)

$R_1 = \frac{U_1^2}{P} = 303\,\Omega$ (formula + calculation: 1 + 1 points).

$R_2 = \frac{U_2^2}{P} = 1323\,\Omega$ (formula + calculation: 1 + 1 points).

Determining the maximum current allowable on each of the resistor wires:

4 points
(may be divided)

$I_{1\max} = \frac{1.1 \cdot U_1}{R_1} = 0.4\text{ A}$ (formula + calculation: 1 + 1 points).

$I_{2\max} = \frac{1.1 \cdot U_2}{R_2} = 0.19\text{ A}$ (formula + calculation: 1 + 1 points).

Determining the maximum voltage that can be switched onto the resistor wires connected in series:

4 points
(may be divided)

As the maximum current through the resistors connected in series may only be the smaller of the two values, $I_{max} = 0.19$ A (2 points), so

$U_{\max} = I_{\max} \cdot (R_1 + R_2) = 309\text{ V}$ (formula + calculation: 1 + 1 points).

Total: 12 points

Problem 3

Data: R = 120 000 km, T = 8 nap, $\gamma = 6.67 \cdot 10^{-11}\ \dfrac{\mathrm{N \cdot m^2}}{\mathrm{kg^2}}$.

Formulating the dynamical condition of moving in a circular orbit around the planet:

4 points
(may be divided)

The gravitational force on the spacecraft is equal to the centripetal force (2 points):

$\gamma \dfrac{m \cdot M}{R^2} = m \cdot \dfrac{v^2}{R}$ (writing down the two sides of the equation 1 + 1 points).

Determining the mass of the planet:

6 points
(may be divided)

As $v = \dfrac{2 \cdot \pi \cdot R}{T}$ (1 point),

thus: $\gamma \dfrac{M}{R^2} = \dfrac{4 \cdot \pi^2 \cdot R}{T^2} \Rightarrow M = \dfrac{4 \cdot \pi^2 \cdot R^3}{T^2 \cdot \gamma} = 2.14 \cdot 10^{24}$ kg
(substitution + rearrangement + calculation 1 + 2 + 2 points).

Total: 10 points

Problem 4

Data: $m = 10$ kg, $p_0 = 10^5$ Pa, $t = 20$ °C, $V = 10$ l, $A = 100$ cm^2, $P = 6$ W, $\Delta t = 3$ minutes,
$\rho = 1.29\ \frac{\text{kg}}{\text{m}^3}$, $c_v = 712\frac{\text{J}}{\text{kg}\cdot\text{K}}$, $g = 9.8\ \frac{\text{m}}{\text{s}^2}$.

a) *Determining the pressure of the enclosed air when it lifts the lid:*

3 points
(may be divided)

$$p_1 = p_0 + \frac{m\cdot g}{A} = 10.98\ \frac{\text{N}}{\text{cm}^2} \approx 11\ \frac{\text{N}}{\text{cm}^2}$$

(formula + substitution + calculation, 1 + 1 + 1 points).

Determining the air-temperature necessary for lifting the lid:

3 points
(may be divided)

$$\frac{p_0}{T_0} = \frac{p_1}{T_1} \Rightarrow T_1 = T_0 \cdot \frac{p_1}{p_0} = 322\ \text{K}$$

(formula + transformation + calculation, 1 + 1 +1 points).

b) *Determining the amount of heat required for warming the air:*

3 points
(may be divided)

$$Q = \rho\cdot V\cdot c_v\cdot(T_1 - T_0) = 266\ \text{J}$$

(formula + substitution + calculation, 1 + 1 + 1 points).

c) *Determining the efficiency of the heating:*

4 points
(may be divided)

The heat released by the heating element:
$Q' = P\cdot\Delta t = 1080\ \text{J}$ (formula + calculation, 1 + 1 points),

from which the efficiency in question:
$\eta = \frac{Q}{Q'} = 0.246 \approx 25\%$ (formula + calculation, 1 + 1 points).

Total: 13 points