ÉRETTSÉGI VIZSGA • 2020. május 19.

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 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. C
2. C
3. B
4. C
5. C
6. B
7. A
8. A
9. D
10. D
11. A
12. B
13. B
14. B
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. The Earth Similarity Index - ESI

a) Reviewing the concept of escape velocity:

2 points

The escape velocity is the velocity which, if attained by an object, allows it to leave the vicinity of the planet, to break free of its gravitational attraction.

b) Listing the factors that the surface gravitational acceleration depends on:

2 points

The mass (or density) of the planet (1 point) and its radius (1 point). (Writing a formula is not necessary.)

c) Naming the mechanism of energy transport between stars and planets:

2 points

The energy from stars to planets is transported via electromagnetic radiation across space. (The expression heat radiation is also acceptable.)

d) Naming the factors that influence surface temperature and explaining why they are ignored:

4 points

The existence of an atmosphere (1 point) and heat generating processes inside the planet (1 point). The ESI index does not take these into consideration because they are known only in a few cases (2 points). (If the student does not mention internal heat generating processes, but instead mentions the density and composition of the atmosphere as separate factors, full points are to be awarded.)

e) Comparing the surface temperature and planetary equilibrium temperature of Earth and explaining the difference between the two:

3 points

The surface temperature of Earth is higher (1 point) than its planetary equilibrium temperature. The primary cause for this is the greenhouse effect caused by the atmosphere (2 points).

f) Naming the planet most similar to Earth and justifying the similarity:

3 points

Out of the planets in the table, Mars (1 point) is the most similar to Earth. It is for this planet that both the surface escape velocity (1 point) and the surface temperature (1 point) is closest to that of Earth.

g) Naming the most important difference between Pluto and the Moon:

2 points

The surface temperature of Pluto differs much more from that of Earth than the temperature of the Moon. (Or: it is much lower than that of the Moon.)

Total **18 points**

2. The radioisotope thermoelectric generator (RTG)

a) *The short review of radioactive decay types:*

3 points

α- decay – helium nucleus (1 point) (simply writing "alpha-particle" is not sufficient),
β-decay – electron (1 point),
γ- decay – electromagnetic radiation (1 point).

b) *Explaining the generation of heat:*

2 points

The energy of the emitted particle is absorbed by the environment (2 points), heats it.

(If the student offers an alternative, physically sound formulation of the fact that energy is released which heats the environment, the answer should be accepted.)

c) *Describing the connection between half life and power:*

2 points

When the half life is shorter, there are more decays per unit time (1 point), which releases more energy per unit time (1 point).

d) *Naming the advantage of an α-emitter isotope:*

2 points

α-radiation is absorbed in a short distance (2 points). If the student expresses this fact by saying that this is the least penetrating or most easily shielded decay type of the three, the answer must be accepted.

e) *Naming the decay product element:*

2 points

The uranium (1 point) 234 (1 point) isotope.

f) *Explaining the placement of the insulation:*

4 points

As the voltage generated by the thermocouple is greater if the temperature difference is larger (2 points) between the two endpoints, it is practical to prevent (impede) heat exchange between the inner (heated) and outer (cooled) side (2 points).

g) *Determining the power reduction:*

3 points

48 years (1 point) after launch, power is $2^{-\frac{48}{88}}$ times the initial power (1 point) which is 0.685, i.e. approximately 69% (1 point).

Total **18 points**

3. Waves

a) Giving the definition for transversal and longitudinal waves:

1 + 1 points

Giving the wave properties and the relationships between them:

1 + 1 points

Wavelength, period or frequency, speed and the relationship between these in pairs, 1 + 1 points.

b) Naming three wave phenomena and mentioning everyday examples:

1 + 1 + 1 points

The wave phenomena are basically mentioned in the problem text. The points are to be awarded for mentioning an example observable in everyday life (with naming the wave phenomenon).

c) Explaining the two-slit experiment for light:

5 points

Giving the conditions for constructive and destructive interference (1 + 1 points) in general, application of the condition for the description of constructive and destructive interference in the case of two slits, for a point on a screen much farther than the slit distance (2 points). Giving the appropriate geometrical relationship (1 point).

d) Explanation of the phenomenon of polarization, differentiating between transversal and longitudinal waves using polarizability:

1 + 1 points

e) Reviewing the experiment that proves the wave nature of electrons:

2 points

For example electron interference on a natural lattice or two-slit interference with an electron beam.

f) Explaining the contradiction between this result and the particle nature:

2 points

The image drawn by impacts on the screen looks different for particle-like behavior.

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: $l = 1$ m, $\alpha = 60°$, $g = 9.8$ m/s^2.

The dynamical interpretation of the object's motion:

2 points

The sum of the gravitational force and the string force acting on the object keep it on the circular trajectory in a horizontal plane.

(Any formula or drawing that expresses this clearly is acceptable. If the student does not draw or write this down, but later evidently performs his/her calculation according to this, full points are to be awarded.)

The correct interpretation of the geometrical relationships:

3 points
(may be divided)

$F_k \cdot \sin\alpha = m \cdot r \cdot \omega^2$ (1 point), $F_k \cdot \cos\alpha = G$ (1 point) or $G \cdot \tan\alpha = m \cdot r \cdot \omega^2$ (2 points),

$l \cdot \sin\alpha = r$ (1 point).

Determining the frequency:

6 points
(may be divided)

$m \cdot g \cdot \tan\alpha = m \cdot r \cdot \omega^2$ (2 points), from which

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l \cdot \cos\alpha}} = 0.705\ \frac{1}{\text{s}}$$

(rearrangement 2 points, substitution of data 1 point, calculation 1 point).

Total: 11 points

Problem 2

Data: $M = 400$ kg, $m = 75$ kg, $V = 2800$ m^3, $t_0 = 20$ °C, $t_1 = 100$ °C, $t_2 = 90$ °C, $g = 9.8$ m/s^2, $\rho_0 = 1.2041$ kg/m^3, $m_{\text{sand}} = 10$ kg.

a) *Determining the density of 100 °C air:*

4 points
(may be divided)

$\rho = \frac{p \cdot M}{R \cdot T}$. As the pressure is constant, $\rho_0 \cdot T_0 = \rho_1 \cdot T_1$ (2 points),

from which $\rho_1 = \rho_0 \frac{T_0}{T_1} = 1.2041 \cdot \frac{293}{373} = 0.9459 \ \frac{\text{kg}}{\text{m}^3}$

(rearrangement and calculation, 1 + 1 point).

Writing down the forces acting on the balloon and determining the maximum number of people:

4 points
(may be divided)

Writing down the weight of the balloon (+ the basket, etc.) and the air inside:
$G_{\text{balloon}} = M \cdot g + \rho_1 \cdot V \cdot g = (400 + 0.9459 \cdot 2800) \cdot g = 3049 \text{ kg} \cdot g$ (1 point).

Writing down the buoyancy force on the balloon:
$F_b = \rho_0 \cdot V \cdot g = 3371 \text{ kg} \cdot g$ (1 point).

Therefore as $N_{\max} \cdot m \cdot g < F_b - G_{\text{balloon}} = 322 \text{ kg} \cdot g$, thus $N_{max} = 4$ (2 points).

b) *Determining the density of 90 °C air:*

2 points
(may be divided)

$\rho_2 = \rho_0 \frac{T_0}{T_2} = 1.2041 \cdot \frac{293}{363} = 0.9719 \ \frac{\text{kg}}{\text{m}^3}$

(formula + calculation, 1 + 1 points).

Writing down the weight of the balloon and determining the number of sand-sacks:

3 points
(may be divided)

$G_{\text{balloon}}' = M \cdot g + \rho_2 \cdot V \cdot g = (400 + 0.9719 \cdot 2800) \cdot g = 3121 \text{ kg} \cdot g$ (1 point).

As the mass of the balloon with the passengers is now 3421 kg (1 point), we need to get rid of 50 kg of ballast, i.e. 5 sacks of sand (1 point) must be thrown out.

Total: 13 points

Problem 3

Data: E = 1 kJ, E_{fission} = 137 MeV, $u = 1.6605 \cdot 10^{-27}$ kg, M_{U} = 235.04 u, T = 30 years.

a) *Writing down the reaction equation:*

5 points
(may be divided)

$^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{96}_{37}\text{Rb} + {}^{137}_{55}\text{Cs} + 3\,{}^{1}_{0}\text{n}$.

(Each term of the equation written down correctly is worth 1 point. Isotopes are acceptable only together with atomic and mass numbers indicated, but for neutrons omission of these numbers is not to be considered a mistake.)

b) *Determining the mass of uranium required for the release of 1 kJ of energy:*

4 points
(may be divided)

The number of fission reactions required for the release of 1 kJ of energy:

$$N = \frac{E}{E_{fission}} = \frac{1 \cdot 10^{3}}{137 \cdot 10^{6} \cdot 1.6 \cdot 10^{-19}} = 4.5620 \cdot 10^{13} \text{ db}$$ (formula + calculation, 1 + 1 points),

from which $m = N \cdot M_U \cdot u = 4.5620 \cdot 10^{13} \cdot 235.04 \cdot 1.6605 \cdot 10^{-27} = 1.78 \cdot 10^{-8}$ g
(formula + calculation, 1 + 1 points).

c) *Determining the time required for the activity to decrease:*

5 points
(may be divided)

As $2^{-\frac{t}{T}} = 0.01$ (2 points),

$-\frac{t}{T} = \log_2 0.01 = -6,6439$ (rearrangement + calculation, 1 + 1 point),

from which $t \approx 200$ years (1 point).

(If the student, using $2^7 = 128$ writes $t = 7 \cdot T = 210$ years for the solution, full points are to be awarded.)

Total: 14 points

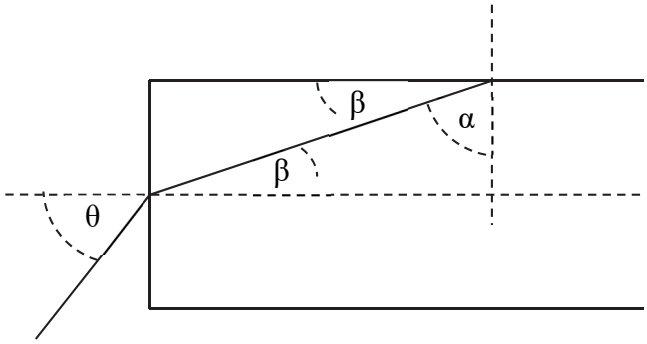
Problem 4

Data: $n = 1.36$.

Defining and determining the critical angle at the glass-air boundary:

4 points
(may be divided)

Defining the angle of incidence (in text or with a drawing) for which the critical angle is defined (marked with α on the adjacent drawing), (2 points).



Determining the critical angle:

$$\sin \alpha_h = \frac{1}{n} \Rightarrow \alpha = 47.3°$$

(formula + calculation, 1 + 1 points).

Determining the angle of incidence that corresponds to the calculated critical angle:

5 points
(may be divided)

As the angle of refraction that corresponds to the crossing of the end surface is $\beta = 90° - \alpha$ (2 points),

$$\frac{\sin \Theta}{\sin \beta} = n \Rightarrow \sin \Theta = \sin \beta \cdot n \Rightarrow \Theta = 67.3°$$

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

Total: 9 points