ÉRETTSÉGI VIZSGA • 2024. május 22.

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

2 points for each correct answer.

Total 30 points

PART TWO

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

1. Hubble's law

a) *Listing wave properties and writing down the relationships between them:*

3 points

λ wavelength, f frequency (or T period), v velocity, A amplitude
(4 quantities are worth 2 points, 3 quantities are worth 1 point)
$v = f{\cdot}\lambda$ (or: $v = \lambda/T$) (1 point)

b) *Explanation of the Doppler phenomenon:*

4 points

Preparing a correct drawing that depicts how the wave-fronts become denser before the moving source and that the wave-fronts become rarer after it (2 points),
wave source approaching: λ decreases (1 point),
wave source is moving away: λ increases (1 point).

c) *Describing the frequency change:*

2 points

The frequency we detect for an approaching wave source is increased (1 point), while for a source moving away it is decreased (1 point).

d) *Giving a suitable example:*

2 points

For example: a vehicle approaching or moving away – any correct example may be accepted.

e) *Answering the question concerning the Solar System:*

2 points

<u>No</u> (1 point), because these <u>do not move away from us</u> (1 point) (on the average, on any perceivable scale).

f) *Explaining how the Big Bang theory is supported:*

2 points

If we reverse the expansion in time, we conclude that the celestial bodies started out from one point at the same instant. This is the instant of the Big Bang.

g) *Determining the speed in question:*

3 points

$$v = H \cdot D = 22.7 \cdot 61 = 1385 \approx 1400 \ \frac{\text{km}}{\text{s}}$$

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

Total **18 points**

2. ITER

a) *Reviewing nucleons and the nuclear interaction:*

5 points

Nucleons are the particles that make up the atomic nucleus (1 point), the proton with a positive electric charge (1 point) and the neutron without a charge (1 point). The nuclear (strong) interaction acts between the nucleons (1 point), has a short range (1 point) and is attractive (1 point).

b) *Reviewing nuclear fusion:*

2 points

The merging, uniting of atomic nuclei (1 point).
Energy is released during the fusion of light nuclei (1 point).

c) *Naming the significance of fusion in nature:*

1 point

In the energy production in stars.

d) The temperature and pressure inside the stars is very high. It is difficult to contain matter with high temperature (plasma).

2 points

e) *Writing down the reaction equation:*

2 points

${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$

Full points are to be given only if the student also indicates the atomic and mass numbers of the isotopes – in their absence only 1 point can be given. If only the neutron is missing these numbers, full points are to be given.

f) *Determining the masses in question:*

3 points

Since the 0.5 g of fuel (1 point) used is divided between deuterium and tritium in the ratio of mass numbers (1 point), approximately 0.2 g of deuterium and 0.3 g of tritium (1 point) is consumed during one stage of operation.

g) *Determining the number of atomic nuclei in question:*

3 points

The 0.2 g of deuterium, as it consists of two nucleons per nucleus:

$N = \dfrac{0{,}2\ \mathrm{g}}{2 \cdot 1.67 \cdot 10^{-27}\ \mathrm{g}} = 6 \cdot 10^{25}$ (formula + calculation, 1 + 1 points)

and the same number of tritium nuclei are required (1 point).

(Any similar train of thought is to be accepted.)

Total **18 points**

3. Motion in a gravitational field

a) *Writing down the general law of gravitation:*

1 point

b) *Giving the data that determine the gravitational acceleration measurable on Earth's surface:*

1 point

c) *The equations of motion for free-fall:*

2 points

displacement–time and velocity–time functions

d) *The displacement and velocity of an object thrown vertically upward and their interpretation:*

4 points

Writing down and interpreting the velocity–time (2 points) and displacement (height)–time functions.

e) *Plotting the acceleration–time graph of a body thrown vertically upward:*

1 point

f) *Giving the definition for the first and second cosmic velocity:*

2 points

g) *Comparing the velocity of the International Space Station with the first cosmic velocity and explaining the difference:*

2 points

The velocity of the space station is somewhat smaller than the cosmic velocity. Justification: e.g. Kepler's 3rd law, or writing down the velocity for a circular orbit with radius *R*.
(It is not sufficient to say only that the space station is above Earth's surface.)

h) *Explaining the state of weightlessness and interpreting it for the case of the International Space Station:*

2 points

i) *Discussing the stages of an interplanetary travel where there is weightlessness and justifying the state of weightlessness on these stages:*

3 points

There is weightlessness when the spaceship is moving freely in the gravitational field of the celestial bodies (or when the spaceship does not use its thrusters) (1 point). Because at this time there is no supporting force as they accelerate under gravitation as their environment (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: P = 10 MW, R = 10 Ω, U_1 = 25 kV, U_2 = 100 kV

a) *Determining the power loss and the power consumed by the city in the first case:*

5 points (may be divided)

The current in the transmission line in the first case:

$I_1 = \dfrac{P}{U_1} = \dfrac{10\ \text{MW}}{25\ \text{kV}} = 400\ \text{A}$ (formula + calculation, 1 + 1 points)

The power loss on the transmission line:

$P_{loss} = I_1^2 \cdot R = 400^2 \cdot\ 10 = 1.6\ \text{MW}$

(formula + calculation, 1 + 1 points),

from which the power consumed by the city is:

$P_{city} = P - P_{loss} = 8.4\ \text{MW}$ (1 point).

b) *Determining the power loss and the power consumed by the city in the second case:*

5 points (may be divided)

The current in the transmission line in the second case:

$I_2 = \dfrac{P}{U_2} = \dfrac{10\ \text{MW}}{100\ \text{kV}} = 100\ \text{A}$ (formula + calculation, 1 + 1 points).

The power loss on the transmission line:

$P'_{loss} = I_2^2 \cdot R = 100^2 \cdot\ 10 = 100\ \text{kW} = 0.1\ \text{MW}$

(formula + calculation, 1 + 1 points),

from which the power consumed by the city is:

$P'_{city} = P - P'_{loss} = 9.9\ \text{MW}$ (1 point).

Total: 10 points

Problem 2

Data: $v_0 = 250$ m/s, $m = 2$ g, $M = 500$ g, $s = 1$ m.

Writing down the conservation of momentum for the collision and determining the common speed:

5 points
(may be divided)

Stating that momentum is conserved during the collision is worth 2 points (in any form, in words or using a formula, e.g.: $m \cdot v_0 = (m+M) \cdot v_c$),

from which:

$$v_c = \frac{m}{m+M} \cdot v_0 = 0.996 \approx 1 \ \frac{\mathrm{m}}{\mathrm{s}}$$

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

Stating the work-energy principle for the stopping of the slab and determining the coefficient of friction:

7 points
(may be divided)

Stating the work-energy principle in any form is worth 2 points (e.g. $E_{kin} = W_f$),
therefore:

$\frac{1}{2}(m+M) \cdot v_c^2 = \mu \cdot (m+M) \cdot g \cdot s$ (Writing down the two sides of the equation, 1 + 1 points),

from which

$$\frac{1}{2} \cdot \frac{v_c^2}{g \cdot s} = \mu = 0.05$$

(rearranging the formula + substitution of data + calculation, 1 + 1 + 1 points).

Total: 12 points

Problem 3

Data: A = 10 cm^2, V_0 = 100 cm^3, T_0 = 20 °C, p_0 = 10 N/cm^2, M = 2 kg, D = 10 N/cm,
g = 9.8 m/s^2.

a) Determining the volume change of the gas due to the weight using Boyle-s law:

3 points
(may be divided)

After placing the weight on, the pressure of the gas is: $p_1 = p_0 + \frac{M \cdot g}{A}$ (1 point), so

$V_1 = \frac{V_0 \cdot p_0}{p_1} = 83.6 \approx 84 \text{ cm}^3$ (formula + calculation, 1 + 1 points).

Realizing that the increased pressure compresses the spring that supports the lower piston:

1 point

Writing down and calculating the compression of the spring:

2 points
(may be divided)

$\Delta l = \frac{M \cdot g}{D} = 1.96 \approx 2 \text{ cm}$ (formula + substitution and calculation, 1 + 1 points)

Determining the amount by which the upper piston is lowered:

2 points
(may be divided)

$\Delta h = \frac{V_0 - V_1}{A} + \Delta l = 3.6 \text{ cm}$ (formula + substitution and calculation, 1 + 1 points)

b) Determining the temperature in question using Gay-Lussac's law:

5 points
(may be divided)

The second process is isobaric, so: $\frac{V_2}{T_2} = \frac{V_1}{T_0}$ (1 point).

Realizing that the spring's compression does not change (1 point)

$V_2 = V_1 + \Delta h \cdot A$ (1 point),

therefore $T_2 = T_0 \cdot \frac{V_2}{V_1} = (273 + 20) \cdot \frac{120}{84} = 419 \text{ K} \rightarrow 146 \text{ °C}$
(formula + substitution, calculation, 1 + 1 points).

The temperature in question may be given in either degrees Celsius or Kelvin.

Total: 13 points

Problem 4

Data: $m_n = 1.6749 \cdot 10^{-27}$ kg, $m_p = 1.6726 \cdot 10^{-27}$ kg, $m_D = 3.3436 \cdot 10^{-27}$ kg,
$h = 6.63 \cdot 10^{-34}$ Js, $c = 3 \cdot 10^{8}$ m/s.

Determining the mass defect and writing down the mass-energy equivalence principle for the minimum photon energy:

6 points
(may be divided)

$\Delta m = m_p + m_n - m_D = 3.9 \cdot 10^{-30}$ kg
(formula + substitution of data + calculation, 1 + 1 + 1 points),

$E_{f,min} > \Delta m \cdot c^2$ (3 points – writing equality can also be accepted).

Determining the minimum frequency and answering the question:

6 points
(may be divided)

$E_f = h \cdot \nu$ (1 point), so:

$\nu > \dfrac{\Delta m \cdot c^2}{h} = 5.3 \cdot 10^{20} \dfrac{1}{\text{s}}$ (formula + substitution of data + calculation, 1 + 1 + 1 points).

Therefore for $\nu < \dfrac{\Delta m \cdot c^2}{h} = 5.3 \cdot 10^{20} \dfrac{1}{\text{s}}$ <u>the process will definitely not take place</u> (2 points).

Total: 12 points

The sources of the problem sheet (picture, drawing, data) can be found at:

I/11. https://commons.wikimedia.org/wiki/File:Aluminium_foam.jpg
II/1. https://en.wikipedia.org/wiki/NGC_1300#/media/File:Hubble2005-01-barred-spiral-galaxy-NGC1300.jpg
II/2. The text of the problem was created by modifying the original source (shortening, grammatical simplification) while retaining the integrity of the original text. The source of the original text is: https://hu.wikipedia.org/wiki/ITER
https://hu.wikipedia.org/wiki/ITER#/media/F%C3%A1jl:ITER_site_2018_aerial_view_(41809720041).jpg
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