ÉRETTSÉGI VIZSGA • 2019. május 20.

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

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

Total 30 points.

PART TWO

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

Comparing rotation and translation

a) *Comparing the kinematic and dynamical quantities characterizing the motion of a point-like body along a straight line (distance, velocity, acceleration, mass, force) with those describing the rotation of an extended, rigid body around a fixed axis and explaining the correspondence between them:*

1+1+1+1+1 points

(The correspondence between the quantities must be explained in each case, the points cannot be awarded otherwise.)

b) *The fundamental dynamical equation of the motion, the condition for uniform motion:*

1+1+1+1 points

c) *Defining the energy characterizing the motion in the two cases:*

1+1 points

d) *Determining the overall kinetic energy of a rolling cylinder:*

3 points

The energy of the translation (center of mass) (1 point), rotational energy (1 point), the relationship between translation and rotation (1 point).

e) *Explanation of the concepts of momentum and angular momentum, demonstration of the conservation laws on two practical examples:*

1+1+1+1 points

Total **18 points**

The position of electrons in the atom

a) *Review of the types of quantum numbers:*

1+1+1 points

Naming the magnetic quantum number is not necessary. Should the student name it instead of the spin, the one point should be awarded.

b) *Formulation of the Pauli principle:*

1 points

c) *Reviewing the possible values of quantum numbers:*

2+2+2 points

d) *Reviewing Hund's rule:*

2 points

e) *Explaining the order in which electron shells are filled in the periodic table:*

2 points

f) *Determining the connection between the quantum numbers of the outermost electron and the position occupied by the element in the periodic table:*

2 points

g) *A general explanation of the periods, groups and blocks of the periodic table:*

2 points

Total 18 points

The life of the Sun and the stars

a) *Reviewing the energy production mechanism within the interior of stars:*

2 points

b) *Reviewing the material composition of the Sun, determining the fuel and end-product of the energy production process:*

2 + 1 + 1 points

c) *Determining the Sun's current surface temperature:*

1 point

d) *Determining the Sun's place within the groups of stars. Naming another star in this group and comparing its luminosity to that of the Sun:*

2 + 1 + 1 points

e) *Identifying the group of red giants on the diagram and naming a red giant star:*

2 + 1 points

f) *Identifying the group of white dwarfs on the diagram. Estimating the surface temperature and luminosity of the Sun in the final phase of its life as a white dwarf using the diagram:*

2 + 1 + 1 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

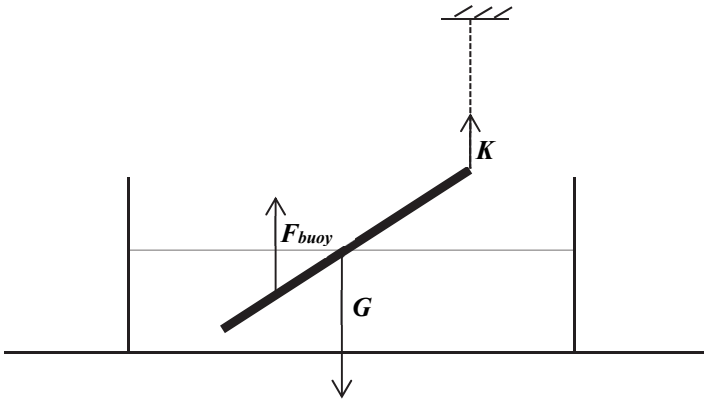
Data: $m = 0.5$ kg, $g = 9.8\ \frac{\text{m}}{\text{s}^2}$, $\rho_{water} = 1\frac{\text{g}}{\text{cm}^3}$

Determining the tension in the rope:

7 points
(may be divided)

Preparing a drawing that correctly depicts the forces acting on the rod with their lines of action and points of application: 2 points

(It is not necessary to prepare a drawing. If later on, e.g. when writing a torque equation the relationships between the forces and their lever arms are correct, full points are to be awarded.)



Writing the torque equation for the equilibrium position of the rod correctly: 2 points.
e.g. Denoting the length of the rod as l and taking the top end as fulcrum:
$F_{buoy} \cdot \frac{3l}{4} = G \cdot \frac{l}{2}$ or $F_{buoy} \cdot \frac{3l}{4} \cdot \cos\alpha = G \cdot \frac{l}{2} \cdot \cos\alpha$.
(If the torque equation is written without the inclination angle and the student does not even mention the role of the angle, one point is to be deduced.)
From which: $F_{buoy} = \frac{2}{3} \cdot G$ (1 point) $\Rightarrow K = G - F_{buoy} = \frac{1}{3} \cdot G = 1.63$ N (formula + calculation, 1 + 1 points).

Determining the density of the rod:

5 points
(may be divided)

As $F_{buoy} = \rho_{water} \cdot g \cdot V / 2$ (1 point) – V is the rod's volume – and $\rho_{rod} \cdot g \cdot V = m \cdot g$ (1 point), from their ratio:
$\frac{\rho_{rod}}{\rho_{water}} = \frac{m \cdot g}{2 \cdot F_{buoy}}$ (1 point) $\Rightarrow \rho_{rod} = \rho_{water} \cdot \frac{G}{2} \cdot \frac{3}{2G} = 0.75\ \frac{\text{g}}{\text{cm}^3}$ (transformation + calculation, 1 + 1 points).

Total: 12 points

Problem 2

Data: $T_A = 1000$ years, $T_B = 2000$ years, $T_C = 10000$ years, $A_A = 6 \cdot 10^7$ Bq, $A_B = 2 \cdot 10^6$ Bq, $A_C = 1.2 \cdot 10^5$ Bq, $A_{threshold} = 4$ Bq, $t = 10000$ years.

a) *Determining the activities after 10000 years:*

5 points
(may be divided)

As $A' = \frac{A}{2^{t/T}}$ (2 points), therefore:

$A_A' = \frac{A_A}{2^{10}} = 5.86 \cdot 10^4$ Bq (1 point),

$A_B' = \frac{A_B}{2^5} = 6.25 \cdot 10^4$ Bq (1 point),

$A_C' = \frac{A_C}{2} = 6 \cdot 10^4$ Bq (1 point).

(It is not necessary to write down the general formulation of the decay law. If the student performs the calculations according to it, full points are to be awarded.)

b) *Determining the time intervals during which the activities of each of the isotopes decay below threshold:*

5 points
(may be divided)

For each isotope, the relationship $4 \text{ Bq} \geq A'' = \frac{A}{2^n}$ (2 points) must be used to determine precisely how many half-lives must have passed for the activity to have decreased below 4 Bq. Thus:

$n_A = 24 \rightarrow t_A = 24000$ years (1 point),
$n_B = 19 \rightarrow t_B = 38000$ years (1 point),
$n_C = 15 \rightarrow t_C = 150000$ years (1 point).

(It is sufficient to determine the lowest integer multiple of the half-life, it is not necessary to calculate the exact times using logarithm calculus.)

Determining the necessary storage time and naming the isotope that necessitates this:

1 + 1 points

Because of <u>isotope C</u> the waste must remain in safe storage for about <u>150000 years</u>.

Total: 12 points

Problem 3

Data: $v = 4 \cdot 10^{6}$ m/s, $B = 10^{-6}$ T, $m = 1.67 \cdot 10^{-27}$ kg, $q = 1.6 \cdot 10^{-19}$ C, $t_1 = 1$ s, $t_2 = 0.1$ s.

a) *Interpretation of the dynamics of motion along a circular orbit in a plane perpendicular to the magnetic field:*

4 points
(may be divided)

When moving along a circular orbit in a plane perpendicular to the magnetic field, the centripetal force is equal to the Lorentz-force, i.e.:

$$q \cdot B \cdot v_{\perp} = m \cdot \frac{v_{\perp}^2}{r}$$

(Equating the two forces is worth 2 points, the correct formulation of the Lorentz-force and the centripetal force is worth another one point each. The points for the formulation are acceptable only if the student makes it clear – using trigonometric functions or appropriate markings – that it is the component of the velocity perpendicular to the field that enters the equation.)

Determining the number of revolutions:

4 points
(may be divided)

From this $\frac{q \cdot B}{m} = \frac{v_{\perp}}{r} = \omega = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi \cdot m}{q \cdot B} = 6.56 \cdot 10^{-2}$ s (rearranging the formula + calculation, 2 + 1 points),
i.e. the proton completes t_1 / T = 15.2 revolutions (1 point) per second.

b) *Realizing that the magnitude of the proton's velocity is constant:*

2 points

c) *Determining the length of the trajectory:*

2 points
(may be divided)

$s = v \cdot t_2 = 4 \cdot 10^5$ m (formula + calculation, 1 + 1 points).

Total: 12 points

Problem 4

Data: $C = 10$ pF, $f = 1.18 \cdot 10^{10}$ Hz, $U_{max} = 2$ V.

a) *Determining the inductance of the coil:*

4 points
(may be divided)

$$f = \frac{1}{2\pi\sqrt{L \cdot C}} \Rightarrow L = \frac{1}{(2\pi \cdot f)^2 \cdot C} = 1.82 \cdot 10^{-11} \text{ H}$$

(formula + rearrangment + calculation, 2 + 1 + 1 points)

b) *Determining the energy of the oscillation:*

3 points
(may be divided)

$E = \frac{1}{2} C \cdot U_{max}^2 = 20$ pJ (formula + calculation, 2 + 1 points).

c) *Determining the maximum current:*

4 points
(may be divided)

$$E = \frac{1}{2} L \cdot I_{max}^2 \Rightarrow I_{max} = \sqrt{\frac{2E}{L}} = 1.48 \text{ A}$$

(formula + rearrangment + calculation, 2 + 1 + 1 points).

Total: 11 points