ÉRETTSÉGI VIZSGA • 2022. május 17.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

minden vizsgázó számára

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

a) *A brief review of the electromagnetic spectrum:*

3 points

At least the following domains should be named: radio-waves, infra-red, visible light, ultra-violet, x-ray (röntgen), gamma-, cosmic-radiation.
(Naming each domain is worth 0.5 points. The final score is to be determined by rounding, but half points are to be rounded down.)

b) *Analysis of the trends of the graph:*

4 points

As the temperature of a body increases, the overall intensity of the emitted radiation increases (2 points), while the wavelength corresponding to the maximum intensity decreases (2 points).

c) *Naming the type of radiation emitted by the human body with greatest intensity:*

2 points

It is visible on the graph that the radiation lies in the 5-20 μm wavelength range, which falls in the infra-red domain.

d) *Naming three suitable examples:*

6 points

Any sensible example may be accepted, e.g. radiator – heats via infra-red radiation; night-vision equipment – detects the heat radiation emitted by bodies in the dark; heat camera – examines the heat loss or gain of various objects; the signal of remote control devices – infra-red waves, etc.

e) *Discussing the role of laser beams:*

3 points

As lasers form long, narrow and straight beams, contrary to ordinary light sources (1 point), the two beams cross at a well-defined distance. Therefore if the camera is held at the proper distance, the two laser spots are coincident (2 points).

Total **18 points**

2. The photoelectron-multiplier

a) A brief review of the photoelectric effect:

6 points

During the photoelectric effect light (1 point) causes the emission of electrons (1 point) from a metal. The electron is emitted if the work function of the metal is smaller than the photon energy (2 points).
$E_{\text{max}} = E_{\text{photon}} - W$ (2 points)

b) Explaining the mechanism of electron multiplication:

4 points

Electrodes are held at different potentials (2 points) (or: there is electric tension between them), so there is an electric field (1 point) which accelerates electrons (1 point).

c) Determining the energy of the 1 eV electron upon reaching the first dynode:

2 points

The 1 eV electron accelerates to about 101 eV (2 points) until reaching the first dynode.

d) Determining the required number of electrodes:

6 points

Each dynode multiplies the number of electrons approximately ten times (2 points).

1.6 pC = $1.6 \cdot 10^{-12}$ C, which is the charge of about 10^7 electrons (2 points).

Thus the primary electron must be multiplied by about a factor of 10^7, for which 7 electrodes (2 points) are necessary.

Total **18 points**

3. Nuclear fission

a) Reviewing the process of nuclear fission:

1 point

b) Explaining the difference between α-decay and nuclear fission:

2 points

During α-decay, He nuclei are emitted from the atomic nucleus. During fission the nucleus splits into decay products with smaller atomic number.

c) Comparing the probability, activation energy of α-decay and nuclear fission and the energy released in the two processes:

2 points

Nuclear fission occurs much more rarely because its activation energy is much greater than that of α-decay. Nuclear fission releases much more energy than α-decay.

d) Elaborating the role of neutron capture:

2 points

With neutron capture, the nucleus becomes unstable and this increases the probability of nuclear fission.

e) Comparing the proton to neutron ratio in fissile nuclei to that in stable decay products:

2 points

There is a large neutron surplus in fissile nuclei, whereas in the stable decay products this surplus is smaller.

f) Reviewing the process of chain reaction:

1 point

g) Explaining the concept of multiplication factor:

2 points

h) Explaining the connection between the multiplication factor and the time dependence of chain reaction:

3 points

$k < 1$; $k = 1$; $k > 1$

i) Explaining the functioning of the tools used to regulate the chain reaction in power plants:

2 points

Control rods: they absorb neutrons, so the multiplication factor can be controlled by raising or lowering them. Or by changing the concentration of neutron absorbing boron in the water. (Mentioning one possibility is sufficient.)

j) Naming Leó Szilárd:

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: $\alpha = 28°$, $g = 9.8\ \text{m/s}^2$, $s = 2.5\ \text{m}$, $t = 4\ \text{s}$.

Determining the coefficient of static friction:

6 points
(may be divided)

At the moment of slippage (borderline situation) the maximum of the static friction force equals the component of gravitational force parallel to the plank surface (2 points). (This fact needs not be stated explicitly. If the student performs the calculations accordingly, full points are to be awarded.)

$F_t = \mu_t \cdot m \cdot g \cdot \cos\alpha = m \cdot g \cdot \sin\alpha$
(writing the left- and right-handsides correctly with trigonometric functions, 1 + 1 points)

$\Rightarrow \mu_t = \text{tg}\,\alpha = 0.53$ (rearrangement + calculation, 1 + 1 points).

Determining the coefficient of kinetic friction:

8 points
(may be divided)

The acceleration after starting to slip:

$$s = \frac{a}{2}t^2 \Rightarrow a = \frac{2s}{t^2} = \frac{5\ \text{m}}{16\ \text{s}^2} = 0.3125\frac{\text{m}}{\text{s}^2}$$
(formula + rearrangement + calculation, 1 + 1 + 1 points)

At the same time, due to Newton's second law:

$m \cdot a = m \cdot g \cdot \sin\alpha - \mu_0 \cdot m \cdot g \cdot \cos\alpha$ (2 points),

from which: $\mu_0 = \dfrac{g \cdot \sin\alpha - a}{g \cdot \cos\alpha} = 0.5$ (rearrangement + calculation, 2 + 1 points).

Total: 14 points

Problem 2

Data: m = 2 g, l = 25 cm, d = 10 cm, Q = –1 nC, g = 9.8 m/s^2

The correct interpretation of the geometrical relationships of the problem:

2 points
(may be divided)

For example, with a suitable figure that shows that:
- the ball hanging on the thread will be displaced by a distance $d/2$ to the side from the vertical position (1 point) and
- the sum of the vertical gravity force and the horizontal electrostatic force is parallel to the string (1 point).

If, from the solution it is evident that the student performed his/her calculation according to this, full points are to be awarded even in the absence of a drawing or an explanation.

Determining the angle enclosed between the string and the vertical:

2 points
(may be divided)

$\sin\alpha = \frac{d}{2l} \Rightarrow \alpha = 11.5°$ (formula + calculation, 1 + 1 points)

Determining the voltage between the capacitor plates:

7 points
(may be divided)

As $F_E = G \cdot \mathrm{tg}\,\alpha$ (1 point),

$m \cdot g \cdot \mathrm{tg}\,\alpha = \frac{U}{d} \cdot Q$ (2 points), from which

$$U = \frac{d \cdot m \cdot g \cdot \mathrm{tg}\,\alpha}{Q} = \frac{0.1 \cdot 2 \cdot 10^{-3} \cdot 9.8 \cdot \mathrm{tg}\,11.5}{10^{-9}} = 400000\ \mathrm{V}$$

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

Total: 11 points

Problem 3

Data: t_0 = 25 °C, t_1 = 5 °C, ρ = 12.8 g/cm^3

a) Determining the relative humidity:

4 points
(may be divided)

As, according to the table, at 25 °C the water vapor equilibrium density is 23 g/m^3 (2 points), the relative humidity is $\frac{12.8}{23} \cdot 100 \approx 56\%$ (formula + calculation, 1 + 1 points).

b) Determining the dew point using the table:

2 points

The value of the dew point can be read from the table, 15 °C.

c) Determining the amount of water condensing from the air:

3 points
(may be divided)

As, according to the table, at 5 °C the water vapor equilibrium density is 6.8 g/m^3

(1 point),

from 1 m^3 of air 12.8-6.8 = 6 g of water condenses (1 point).

Thus 1200 g water condenses (1 point) overall from the 200 m high column of air above 1 m^2 area of the ground.

d) Determining the pressure of water vapor:

3 points
(may be divided)

The density of water vapor is 6.8 g/m^3. Therefore, in a volume of 1 m^3 there is

$n = \frac{6.8\ g}{18\ g/mol} = 0{,}377\ mol$ water vapor. (1 point)

Using the equation of state for an ideal gas: $p = \frac{nRT}{V} = 872\ \text{Pa}$ (2 points)

(If, instead of performing the calculation, the student obtains the value from the data tables, no points are to be awarded.)

Total: 12 points

Problem 4

Data: $I_1 = 10^{18}$–10^{20} W/cm^2, $R_T = 500$ m, $P_{Sun} = 3.86 \cdot 10^{26}$ W, $R_{SE} \sim 1.5 \cdot 10^{11}$ m, $\eta = 81\%$.

a) Determining the power of Sun's radiation on a 1 m² area of Earth's surface:

5 points
(may be divided)

The radiation of the Sun at Earth's distance is distributed over the surface of a sphere 150 million kilometers in radius (1 point), so the intensity here is:

$$I = \frac{P_{\text{Sun}}}{4R^2_{\text{Sun-Earth}} \cdot \pi} = \frac{3.86 \cdot 10^{26}}{4 \cdot (1.5 \cdot 10^{11})^2 \cdot \pi} \ \frac{\text{W}}{\text{m}^2} = 1365 \frac{\text{W}}{\text{m}^2}$$

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

81% of this reaches the surface: $I_{\text{surf}} = 1106 \,\frac{\text{W}}{\text{m}^2}$. (1 point)

b) Determining the intensity ratio in question:

5 points
(may be divided)

The power on the 500 m diameter concave spherical mirror is:
$P_T = R^2 \pi \cdot I_{\text{surf}} = 250^2 \cdot \pi \cdot 1106 \text{ W} = 2.17 \cdot 10^8 \text{ W}$. (Writing down the relationship + calculation, 1 + 1 points.)

This is the power on every cm² of the 1.2 m diameter circular area:

$$I_{\text{KL}} = \frac{P_T}{R^2 \pi} = \frac{2.17 \cdot 10^8}{60^2 \cdot \pi} \frac{\text{W}}{\text{cm}^2} = 1.92 \cdot 10^4 \frac{\text{W}}{\text{cm}^2}$$

(Writing down the relationship + calculation, 1 + 1 points.)

This intensity is less than the intensity by the pulsed laser by a factor of $\sim 5 \cdot 10^{13} - 5 \cdot 10^{15}$. (1 point)

Total: 10 points