ÉRETTSÉGI VIZSGA • 2023. május 23.

# FIZIKA
# ANGOL NYELVEN

# EMELT SZINTŰ
# ÍRÁSBELI VIZSGA

**minden vizsgázó számára**

# 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. D**
**2. B**
**3. B**
**4. C**
**5. B**
**6. B**
**7. C**
**8. D**
**9. B**
**10. B**
**11. A**
**12. A**
**13. A**
**14. C**
**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. Artificial light and sleep

*a) Reviewing the principal properties of waves and the relationships between them:*

***4 points***

A wave is characterized by a $T$ period (s) and an $f$ frequency (1/s) (1point) which are related by $f = 1/T$ (1 point). Further properties are the $\lambda$ wavelength and the $c$ velocity (1 point), which are related by $c = \lambda \cdot f$ (1 point). (Any other equivalent relationship with $c$ and $\lambda$ in it is also acceptable.)

*b) Giving the frequency range of visible light:*

***2 points***

The frequency of visible light is approximately in the range $4.3 \cdot 10^{14}$ Hz (1 point) – $7.7 \cdot 10^{14}$ Hz (1 point). (If the student starts from the 350 nm – 800 nm range indicated on the figure and, using the formula $c = \lambda \cdot f$ obtains $3.75 \cdot 10^{14}$ Hz (1 point) – $8.6 \cdot 10^{14}$ Hz for the frequency range, full points are to be awarded.)

*c) Naming and explaining a method to decompose white light:*

***3 points***

For example: Light passes through a prism (1 point) and because of dispersion (or the wavelength dependence of the index of refraction) (2 points) it is decomposed into colour light.

*d) Demonstrating the red shift in the wavelength distribution of natural light:*

***2 points***

Around sunset, the highest intensity components that sunlight contains correspond to large wavelengths (or reddish colours) (1 point), whereas around noon they correspond to shorter wavelengths (1 point).

*e) Explaining the connection between the three maxima of mobile phone daylight mode light and the colour generation process:*

***2 points***

The three maxima correspond to red, green and blue colours, the ones used to set the colours of the pixels.

*f) Answering the questions on mobile phone lighting:*

***2 points***

Bluish light obstructs sleep (1 point) and the daytime lighting of mobile phones contains bluish light. Any light inhibits the production of melatonin (1 point) and is therefore detrimental to sleep.

*g) Reading the wavelength corresponding to the highest intensity in the light of a mobile phone in night mode and determining its colour:*

***3 points***

The maximum can be seen on the graph to be in the range 610 – 620 nm (2 points), which is red in colour (1 point). (For the location of the maximum, any value between 600 nm and 630 nm may be accepted. If the student determines the colour as orange, the answer is to be accepted.)

**Total** **18 points**

## 2. The centrifugal governor

*a) Reviewing the quantities characterizing uniform circular motion and the relationships between them:*

***5 points***

The time required for a single rotation, the period $T$ and the number of revolutions per unit time, the rotational speed $f$ (1 point) are related by $f = 1/T$ (1 point).

The angular velocity $\omega = 2\pi/T$ (1 point).

The tangential velocity $v = r \cdot \omega$ (1 point).

The centripetal acceleration is the acceleration pointing toward the center (perpendicular to the velocity): $a_{cp} = v^2/r = r \cdot \omega^2$ (1 point, one of the expressions is sufficient).

*b) Reviewing the dynamical condition for uniform circular motion:*

***2 points***

The net force on the body is constant in magnitude and radial in direction (pointing toward the rotation center).

*c) Sketching the forces that act on the ball:*

***4 points***

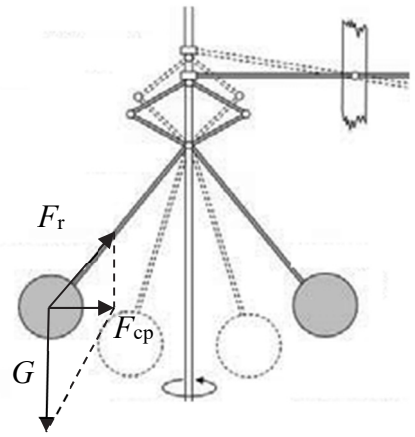
The sketch (and the corresponding explanation) is sufficient, if it is clear that:

The ball is acted upon by gravitation and the force of the rod (1 + 1 points).

The net force due to these two is a force pointing to the rotation center (centripetal force) (2 points).

Or:

The vertical component of the force of the rod is equal in magnitude to the force of gravity (1 point), its horizontal component is a force pointing to the rotation center (centripetal force) (1 point).




*Explaining the motion of the ball:*

***2 points***

If the rotational speed (or ω) increases, the horizontal component of the force of the rod is not large enough (1 point) to hold the ball on the circular trajectory, so it moves outward and upward (1 point).

*d) Explaining the functioning of the governor:*

***5 points***

If the ball moves outward, the hinge with the sliding ring moves down (1 point), so the end of the control rod on this side moves down, consequently on the other side it moves up (1 point). The control rod thus shuts the regulating valve (1 point), so less steam enters the engine and it slows down (1 point). In the opposite case, (the ball moves inward), the regulating valve opens so the engine speeds up (1 point).

**Total** **18 points**

## 3. The equivalence of mass and energy in practice

*a) Reviewing the structure of the nucleus:*

***1 point***

*b) Defining the concepts of atomic number, mass number and isotope:*

***1 + 1 points***

*c) Giving the properties of the nuclear (strong) interaction:*

***2 points***

(Mentioning three properties is worth 2 points, 2 properties is worth 1 point.)

*d) Writing down and interpreting the mass – energy equivalence principle:*

***1 + 1 points***

*e) Defining the concepts of mass defect and binding energy:*

***1 + 1 points***

*f) Explaining the connection between mass defect and binding energy:*

***2 points***

*g) Explaining the principle of a particle accelerator:*

***3 points***

*h) Explaining the concept of the anti-particle, giving an example:*

***1 + 1 points***

*i) Reviewing the phenomenon of pair creation and annihilation:*

***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: $R = 1.5 \cdot 10^{12}$ m, $\gamma = 6.67 \cdot 10^{-11} \ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{kg}^2}$.

*a) Determining the orbital period of the exoplanet:*

***3 points***

Reading the distance between the decreases in light intensity on the graph, we obtain approximately 30 days.

*b) The correct interpretation of the dynamical condition for motion along a circular trajectory under the action of gravity:*

***2 points***

$F_{\mathrm{grav}} = F_{\mathrm{cp}}$ (Should the correct interpretation be evident only later, during the course of the calculations, full points are to be awarded.)

*Determining the mass of the star:*

***6 points***
***(may be divided)***

$$\gamma \frac{m_{\mathrm{exo}} \cdot M_{star}}{R^2} = m_{\mathrm{exo}} \cdot R \cdot \omega^2$$

(writing the left- and the right-hand side of the equation correctly 1 + 1 points).

$$\Rightarrow M_{star} = \frac{4\pi^2 \cdot R^3}{\gamma \cdot T^2} = \frac{4\pi^2 \cdot \left(1.5 \cdot 10^{12}\right)^3}{6.67 \cdot 10^{-11} \cdot \left(30 \cdot 86400\right)^2} = 2.97 \cdot 10^{35} \ \mathrm{kg}$$

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

**Total: 11 points**

## Problem 2

Data: $\Delta t$ = 1 hour 20 minutes, $m$ = 0.02 kg, $N$ = 30, $T_1$ = 15 °C, $T_2$ = −18 °C,
$C_w$ = 4200 J/(kg·K), $L$ = 334 kJ/kg, $C_i$ = 2100 J/(kg·K), $I$ = 0.5 A, $U$ = 230 V.

*a) Writing down and calculating the power of the motor:*

***1 + 1 points***

$P = U \cdot I = 0.5 \cdot 230 = 115$ W.

*b) Determining the heat given off by the ice cube during cooling:*

***7 points***
***(may be divided)***

$$Q = m \cdot C_w \cdot \Delta T_1 - m \cdot L + m \cdot C_i \cdot \Delta T_2$$
$$= -0.02 \cdot 4.2 \cdot 15 - 0.02 \cdot 334 - 0.02 \cdot 2.1 \cdot 18 = -8.7 \text{ kJ}$$

(Writing down the three parts of the formula is worth 1 + 1 + 1 points, determining the two temperature changes correctly is worth 1 + 1 points, substitution of data and calculation 1 + 1 points. No point should be deduced for the absence of the negative sign.)

*c) Determining the heating power of the freezer:*

**5 points**
**(may be divided)**

The freezer will heat the kitchen with a power equaling the power of the motor + the power of cooling: $P_{heat} = P_{motor} + P_{cool}$ (2 points).

The power of cooling: $P_{cool} = \dfrac{N \cdot Q}{\Delta t} = \dfrac{30 \cdot 8700}{80 \cdot 60} \approx 54$ W
(formula + calculation, 1 + 1 points).

Therefore: $P_{heat} = 115 + 54 = 169$ W (1 point).

**Total: 14 points**

## Problem 3

Data: $s = 1$ m, $t = 2$ s, $v_0 = 0.6$ m/s, $g = 9.8$ m/s$^2$.

*a) Determining the final speed:*

***3 points***
***(may be divided)***

$s = \frac{v_0 + v_1}{2} \cdot t \Rightarrow v_1 = 2\frac{s}{t} - v_0 = 0.4 \ \frac{\text{m}}{\text{s}}$

(formula + rearranging the formula + calculation, 1 + 1 + 1 points).

*b) Writing down and calculating the acceleration:*

***1 + 1 points***

$a = \frac{\Delta v}{t} = \frac{-0.2}{2} = -0.1 \ \frac{\text{m}}{\text{s}^2}$ (if the sign is positive, only 1 point is to be awarded).

*c) Determining the coefficient of friction:*

***3 points***
***(may be divided)***

As the body is being decelerated only by the force of friction:

$a = -\mu \cdot g \Rightarrow \mu = \frac{-a}{g} = \frac{0{,}1}{9.8} = 0.01$

(formula + rearranging the formula + calculation, 1 + 1 + 1 points).

*d) Determining the fraction of the kinetic energy that is transformed to heat:*

***4 points***
***(may be divided)***

$\frac{E_1}{E_0} = \frac{v_1^2}{v_0^2} = \frac{0.4^2}{0.6^2} = 0.44$ (formula + calculation, 1 + 1 points).

Therefore <u>56%</u> (2 points) of the initial kinetic energy has been transformed to heat.

**Total: 12 points**

## Problem 4

Data: $R = 0.4\ \Omega$, $d = 1.6$ mm, $\delta = 0.017 \cdot 10^{-6}\ \Omega$ m.

*The correct interpretation of the problem:*

***4 points***

As the two wires in the wall touch, i.e. are electrically connected at a distance $x$ from the socket, we have measured the electrical resistance of a copper wire with length $l = 2x$.

*Writing down the resistance of the wire and determining the distance in question:*

***6 points***
***(may be divided)***

As $R = \delta \cdot \frac{l}{A}$ (2 points), therefore

$$R = \delta \cdot \frac{2x}{\left(\frac{d}{2}\right)^2 \cdot \pi} \rightarrow x = \frac{R \cdot \left(\frac{d}{2}\right)^2 \cdot \pi}{2 \cdot \delta} = \frac{0.05 \cdot \left(8 \cdot 10^{-4}\right)^2 \cdot 3.14}{2 \cdot 1.7 \cdot 10^{-8}} = 3 \text{ m}$$

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

**Total: 10 points**