ÉRETTSÉGI VIZSGA ● 2014. május 19.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI ÉRETTSÉGI 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. The score (0 or 2) should be entered in the table next to the question as well as the table for total scores at the end of the exam paper.

PART TWO

The examinee should present 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 examinee 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 the evaluation. 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

The sentences printed in italics in the evaluation guide define the steps necessary for the solution. The scores indicated here may be awarded if the action or operation described by the text in italics can be clearly identified in the work of the examinee and is basically correct. Wherever the action can be broken down into smaller steps, partial scores are indicated beside each line of the expected solution. The „expected solution" is not necessarily complete; its purpose is to indicate the length and nature of the expected solution, and the depth of detail required of the examinee when writing the solution. Comments in brackets that follow provide further guidance on the evaluation of possible errors, differences or incomplete answers.

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 fraction of the full score may be awarded for correct interpretation of the question, for writing down relationships, for calculations, etc.

Should the examinee 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.

For errors that do not affect the correctness of reasoning (miscalculations, clerical errors, conversion errors, etc.) deduce points only once.

Should the examinee write more than one solutions, or display multiple attempts at solving the problem, and does not indicate clearly which one of those he/she considers the final version, the last one should be evaluated (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 examinee.

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.

PART ONE

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

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

Total: 30 points.

PART TWO

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

1. Torque, equilibrium, levers

Outlining the definition of torque, writing down the relationship, preparing an illustration, definition of the moment arm, assigning the proper unit:

3 points

Formulating the conditions of equilibrium:

2 points

Describing levers of the second and first class, preparing a drawing:

1+1 points

Analyzing the transmission of force and energy:

1+1 points

Presenting one practical application of each in household use:

1+1 points

Explaining how fixed and movable pulleys work using the principles of levers:

2+2 points

Specifying the time period when Archimedes was active and interpreting the sentence quoted:

2 points

Naming the lever of the first class:

1 point

Total 18 points

2. The interference of light

Reviewing the notion of interference:

2 points

Defining the places of amplification and extinction using differences in distance:

2 points

Giving the condition under which interference may be observed:

2 points

The two light waves must be coherent, i.e. their difference in phase must be constant in time.

Describing and explaining the phenomenon of interference of light on an optical grating:

2 points

Specifying the directions of amplification:

2 points

Explaining how the wavelength can be measured:

3 points

Explaining why white light is decomposed into the colors of the spectrum on an optical grating:

2 points

Comparing the spectrum created by an optical grating and that created by a prism:

2 points

An example of colors appearing due to interference:

1 point

Total 18 points

3. The Hubble Space Telescope orbiting around Earth

Naming the most important scientific achievement of Hubble:

1 + 2 points

Galaxies are moving away from us (each other). The farther they are, the faster they move away.

Naming the theory of the Big Bang:

1 point

Summarizing the physical knowledge relevant to the motion of the spacecraft along its trajectory:

2 points

The Space Telescope is orbiting around Earth, it is held on its trajectory by gravitational attraction. (A drawing is also acceptable if it indicates the vector of the gravitational force and the vector of the Space Telescope's tangential velocity correctly.)

Specifying the acceleration of the Space Telescope:

2 points

Naming the advantages of a telescope installed in space:

2 points

Observations are not disturbed by the atmosphere and light pollution.

(Other correct statements are also acceptable.)

Realizing that the pictures taken by the telescope depict an earlier state of the Universe:

3 points

Identifying the solar panels, explaining their role in supplying energy:

2 points

Identifying the role of the spectrograph, specifying the information that can be gained about the stars:

3 points

For example, the material composition, temperature or the velocity of the stars may be mentioned.

Total 18 points

Evaluation of the style of the presentation for all three topics, based on the exam description:

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 is coherent and unanimous as a whole;
- individual parts, subtopics relate to each other along a clear, comprehensible train of thought.

If the review is no more than 100 words in length, no points may be awarded for the style of presentation.

If the examinee's choice of topic is ambiguous, the style of presentation of the last one written down should be evaluated.

PART THREE

Problem 1

Data: m = 20 g (2 dkg), $g = 10\,\frac{\text{m}}{\text{s}^2}$.

a) Calculating the greatest height attained by the ball and the corresponding time:

3 points
(may be divided)

The greatest height is attained by the ball when its velocity becomes zero for the first time at t = 0.3 s (1 + 1 points),

$h_{\max} = \frac{v_0^2}{2g} = 0.45\,\text{m}$ (1point).

b) Calculating the average acceleration of the ball during the first collision:

3 points
(may be divided)

One can determine from the graph, that during the collision $\Delta v_y = 5.75\ \frac{\text{m}}{\text{s}}$ (1 point), and

that $\Delta t = 0.05\ \text{s}$ (1 point), from which $a = 115\ \frac{\text{m}}{\text{s}^2}$ (1 point).

Calculating the average force exerted on the ball by the ground during the first collision:

2 points
(may be divided)

The net force on the ball that accelerates it during the collision:
$m \cdot a = F_{ground} - m \cdot g$ (1 point), from which
$F_{ground} = 2.3\ \text{N} + 0.2\ \text{N} = 2.5\ \text{N}$ (1point).
If the examinee does not take into account the force of gravity and derives the force on the ball due to the ground solely from the acceleration, only one point may be awarded for this part.

c) Determining the number of collisions:

6 points
(may be divided)

Determining the "coefficient of restitution": (1 point)

$$\frac{v_{recoil}}{v_{collision}} = \frac{2.75\,\frac{\text{m}}{\text{s}}}{3\,\frac{\text{m}}{\text{s}}} = 0.917$$

Determining the ratio of the maximum heights before and after the collision (1+1 points)

$$h_{\max} = \frac{v_0^2}{2g}, \quad \text{so} \quad \frac{h_{after}}{h_{before}} = \frac{v^2{}_{recoil}}{v^2{}_{collision}} = 0.917^2 = 0.84$$

So the maximum height after the collision will always be 0.84 times that before the collision.

Determining the number of collisions (3 points, may be divided)

The height after n collisions

$h_n = 0.84^{\mathrm{n}} \cdot h_{\max}$

$0.5 \cdot h_{\max} = 0.84^{\mathrm{n}} \cdot h_{\max}$,

from which $\mathrm{n} = \dfrac{\lg 0.5}{\lg 0.84} = 3.97$

So the maximum height will be reduced to less than half its original value after the fourth collision.

(Correct results may be obtained by other means as well, e.g. it may be deduced directly from the information on the graph.)

Total: 14 points

Problem 2

Data: $t_1 = 15\ °C = 288\ K$, $t_2 = -20\ °C = 253\ K$, $\Delta p = 200\ 000\ Pa$

a) Formulating and calculating the pressure necessary in the garage:

4 points
(may be divided)

The pressure required in the tire is $p_2 = 300\ 000\ Pa$ (1 point),

$\frac{p_1}{T_1} = \frac{p_2}{T_2}$ (2 points), from which $p_1 = p_2 \frac{T_1}{T_2} = 341\,500\ \text{Pa}$ (1 point).

b) Analyzing the change of internal energy:

5 points
(may be divided)

$\frac{E_2}{E_1} = \frac{T_2}{T_1} = \frac{253}{288} \approx 88\% \rightarrow$ The loss of internal energy is ~ 12%.

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

This energy is lost by the air to the environment. (1 point)

c) Comparing the amount of air in the tire and its internal energy for the cases of cold and warm garage:

3 points
(may be divided)

$E_{\text{internal}} = \frac{5}{2}\frac{m}{M} R \cdot T = \frac{5}{2} P \cdot V$ (1 point)

The internal energy is the same in the two cases, because the volumes and the pressures of the air in the tire are both equal (2 points).

Total: 12 points

Problem 3

Data: $R = 0.5$ m, $B = 10^{-4}$ T, $m_\alpha = 6.64 \cdot 10^{-27}$ kg, $e = -1.6 \cdot 10^{-19}$ C, $h = 6.62 \cdot 10^{-34}$ J·s.

Writing down the equation for the motion of the alpha particle in homogeneous magnetic field and calculating its speed:

6 points
(may be divided)

$F_{cp} = F_{Lorentz}$ (1 point)

$m_\alpha \cdot \frac{v^2}{R} = q_\alpha \cdot v \cdot B$ (1 point), from which $v = \frac{q_\alpha \cdot B \cdot R}{m_\alpha}$ (rearranging the formula, 1 point)

Because $q_\alpha = -2 \cdot e = 3.2 \cdot 10^{-19}$ C (1 point),

$v = \frac{0.5 \cdot 3.2 \cdot 10^{-19} \cdot 10^{-4}}{6.64 \cdot 10^{-27}} \frac{\text{m}}{\text{s}} = 2410 \frac{\text{m}}{\text{s}}$ (substitution and calculation, 1 + 1 points).

Formulating and calculating the de Broglie wavelength of the alpha particle:

4 points
(may be divided)

$\lambda = \frac{h}{p}$ (2 points), from which

$\lambda = \frac{6.62 \cdot 10^{-34}}{6.64 \cdot 10^{-27} \cdot 2410} \text{m} = 4.15 \cdot 10^{-11}$ m (substitution and calculation, 1 + 1 points)

(It is not necessary to calculate v to determine the wavelength, because the momentum of the alpha particle can be obtained from the equation for circular motion directly.)

Total: 10 points

Problem 4

Data: $\lambda = 670$ nm, $P = 1$ mW, $c = 3\cdot 10^8\ \frac{\text{m}}{\text{s}}$, $h = 6.62\cdot 10^{-34}$ J·s

a) Determining the energy and momentum of the laser photons:

4 points
(may be divided)

$$E_f = h\cdot\frac{c}{\lambda} = 6.62\cdot 10^{-34}\cdot\frac{3\cdot 10^8}{670\cdot 10^{-9}}\ \text{J} = 2.96\cdot 10^{-19}\ \text{J}$$

(formula + calculation, 1 + 1 points)

$$p_f = \frac{h}{\lambda} = \frac{6.62\cdot 10^{-34}}{670\cdot 10^{-9}}\ \frac{\text{kg}\cdot\text{m}}{\text{s}} = 9.88\cdot 10^{-28}\ \frac{\text{kg}\cdot\text{m}}{\text{s}}$$

(formula + calculation, 1 + 1 points)

b) Determining the number of photons emitted per second:

3 points
(may be divided)

$$N_f = \frac{P}{E_f} = \frac{10^{-3}}{2.96\cdot 10^{-19}}\ \frac{1}{\text{s}} = 3.38\cdot 10^{15}\ \frac{1}{\text{s}}$$

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

(pieces/s or pieces are also acceptable for the physical unit of the photon number.)

c) Determining the force on the laser apparatus:

4 points
(may be divided)

A force acts on the laser apparatus due to the momentum change of the photons, i.e.:

$$F = \frac{\Delta p}{\Delta t} = N_f\cdot p_f = 3.38\cdot 10^{15}\ \frac{1}{\text{s}}\cdot 9.88\cdot 10^{-28}\ \frac{\text{kg}\cdot\text{m}}{\text{s}} = 3.34\cdot 10^{-12}\ \text{N}$$

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

Total: 11 points