ÉRETTSÉGI VIZSGA • 2008. május 14.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI ÉRETTSÉGI VIZSGA

JAVÍTÁSI-ÉRTÉKELÉSI ÚTMUTATÓ

OKTATÁSI ÉS KULTURÁLIS MINISZTÉRIUM

In marking the examination papers follow the instructions of the evaluation guide, making clear corrections and comments.

PART ONE

In the multiple-choice questions, the 2 points are due for the correct answer as given below. Enter the scores (0 or 2) in the grey rectangles next to the individual questions as well as the total score in the table at the end of the question paper.

PART TWO

The candidate should expound his opinions about the chosen topic in a continuous, coherent composition using whole sentences, thus sketchy answers cannot be accepted. The only exceptions are the labels of sketches or explanatory notes added to the figures. Points can only be awarded for the facts or data pointed out in the evaluation guide if they are mentioned in the appropriate context. Tick the correct statements, and write the awarded points to the margin of the sheets, as well as indicate the point in the evaluation guide according to which the credits were given. Also enter the scores in the table below part two.

PART THREE

The lines in the evaluation guide printed in italics define the steps necessary for the solution. The indicated numbers of points are due if the activity or operation described in italics can be clearly identified in the work of the candidate, and it is basically correct and complete. Where the activity can be divided into smaller steps, the subtotals are indicated next to each line of the expected solution. The sample solution as given in the evaluation guide is not necessarily complete. It aims to illustrate what kind of solution (length, types, depth, details, etc) is expected of the candidate. The remarks in brackets at the end of the unit give further guidance in the judgement of possible errors, differences, and incomplete answers.

Correct solutions using a different reasoning from the one(s) given in the evaluation guide are also acceptable. The lines in italics help in judging the appropriate proportions, i.e. what part of the full score can be awarded for the correct interpretation of the question, for setting up relationships between quantities, for calculation, etc.

If the candidate combines steps and expresses the result algebraically without calculating quantities shown by the evaluation guide but not asked for in the original problem, award full mark for these steps, provided that the reasoning is correct. The purpose of giving intermediate results and the corresponding subtotals is to make the marking of incomplete solutions easier.

Take off points only once for errors not affecting the correctness of reasoning (e.g. miscalculations, slips of the pen, conversion errors, etc.)

If the candidate’s response contains more than one solution or more than one attempt without making clear which one they want to be assessed, assume that the last version is the final version (i.e. the one at the bottom of the page if there is no other way to decide the order.) If the candidate’s response contains a mixture of elements of two different chains of reasoning, evaluate only one of the two. Select the one that is more favourable for the candidate.

The lack of units during calculation should not be considered a mistake if it does not cause an error in the result. The answers to the questions asked by the problem, however, are only acceptable with the appropriate units.

PART ONE

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

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

Total **30 points.**

PART TWO

In all the tree parts the subtotals can be further divided.

Topic 1

a) Characterising the motion of the space probe on the elliptical path according to Kepler's second law.

Stating Kepler's second law:

4 points

The line which joins the space shuttle and the Mars sweeps out equal areas in equal times.

(Other correct stating of the law should be accepted, an appropriate figure is acceptable as well. If the candidate states the law generally and does not apply it to the space probe orbiting about the Mars award only 2 points.)

Comparing the speeds of the probe when it is close and far away from the Mars:

3 points

The product of the distance between the probe and the Planet and the speed of the shuttle remains constant.

(If the candidate refers to the fact that further away the speed is smaller and closer it is greater but the inverse proportionality is not mentioned award only 2 points.)

b) Comparing the periods of the elliptical and the circular paths:

1+1+1 point

Because on the elliptical path the mean distance between the shuttle and the Mars is greater than that of on the circular path (the space probe was put to the circular path when it was close to the Mars), thus according to Kepler's third law the time of revolution is greater in case of the elliptical path.

c) Expressing the period and the centripetal acceleration in terms of R and v:

2+2 points

$$T = \frac{2R\pi}{v} \quad , \qquad a_{cp} = \frac{v^2}{R}$$

d) Stating the dynamical condition of uniform circular motion.

2 points

$\vec{F}_e = m\vec{a}_{cp}$, where $\vec{F}_e$ is a constant force pointing towards the centre of the circle.

e) Setting up the expression of the gravitational force:

2 points

$$F = \gamma \frac{M_{Mars} \cdot m_{probe}}{R^2}$$

Total **18 points**

Topic 2

a) Describing the position of the charges:

2 points

The positive charges are on that part of the conductor which is closer to the external electric field, the negative charges are on the opposite side.

(The 2 points are due if the position of the charges are shown on the figure only.)

b) Stating the amount of charges:

2 points

Because the charges are induced charges the algebraic sum of the positive and negative charges is zero.

c) Figure showing the structure of the electric field:

6 points

The correct figure should have the following features:
The lines which were originally parallel are a bit deflected near the sphere (1 point).
The electric field lines are directed from the positive charges towards the negative charges (1 point). The electric field lines are perpendicular to the surface of the sphere (2 point).
Inside the sphere there are no electric field lines (the electric field is zero) (2 points).

(If the candidate mentions later, when he explains electric shielding, that the electric field is zero inside a conductor, the 2 points are due.)

d) Explaining the distribution of excess charges:

2 points

The excess charges are on the surface of the conductor.

e) Describing point discharge at sharp edges, or corners:

2 points

Charges will move onto or away from a conductor through those parts, which are, the most highly curved parts (the corners or pointed parts of the metal).

(It is not necessary to explain the phenomenon.)

f) Protection against lightning:

2+2 points

Using pointed ends, and electric shielding. (Inside the conductor the electric field is zero.)

(To gain the given points it is not necessary to explain the phenomena.)

Total **18 points**

Topic 3

a) Galileo's principle of relativity:

4 points

The laws of mechanics are the same in all reference frames, which move with constant velocity with respect to each other.
or:
Inertial frame of reference is a reference frame in which Newton's laws are true. A reference frame which undergoes uniform straight line motion with respect to an inertial frame of reference is also an inertial frame of reference.

b) The classical velocity-addition method:

2+2 points

$v_1 \pm v_{rel} = v_2$

(Instead of the formula a proper description is acceptable. Award 2 points for the case when the motions are in the same direction and 2 for the case when they are opposite.)

c) The velocity-addition method fails in case of light.

3 points

According to the Michelson-Morley experiment the speed of the Earth is not added to the speed of light.

(To gain the three points it is not necessary to mention the names Michelson and Morley, and to describe the experiment, it is enough to state properly the consequences of the experiment.)

d) The effect of the relative motion of the observers on the measured speed of light.

3 points

(The 3 points are due if the candidate states clearly that the observers who move with respect to each other will measure the same value for the speed of light despite of their relative motion.

e) Accordance with Einstein's principle of relativity

4 points

According to the principle of relativity extended by Einstein the physical constants are the same in those reference frames which move with constant velocity with respect to each other, thus the independence of the light's speed from the velocity of the observer is the consequence of the relativity principle extended by Einstein.

Total **18 points**

Assessing the presentation according to the description of the exam:

Grammar: ***0-1-2 points***

- The essay is clear, understandable and contains grammatically correct sentences.
- There are no spelling mistakes in the scientific terms, names and notations.

Coherence of the text: ***0-1-2-3 points***

- The essay is complete and can be understood as a whole.
- The composition is coherent, the set of ideas described by the candidate is consistent, and clear.

If the candidate wrote less than 100 words, no points can be rewarded for the presentation.

If the chosen topic is not clear, evaluate the one, which was written last.

PART THREE

Problem 1

a) C*alculating the energy of a photon:*

$$E_f = h \cdot \frac{c}{\lambda}$$

2 points

$$E_f = 3.16 \cdot 10^{-19}\,\text{J}$$

2 points

b) *Stating the relationship between the power of light and the total power of photons:*

The total energy for n photons is $n \cdot E_p$

1 point

From the power: $E = P \cdot t$

2 points

Calculating the number of photons:

1+1+1 point

Expressing n, substituting the data, result:

$n = \frac{P \cdot t}{E_p}$, for $t = 1$ s $n = 6.3 \cdot 10^{18}$.

Total **10 points**

Problem 2

Finding the forces exerted on the scale and comparing them to the reading on the scale:

4 points
(it can be further divided)

Because the scale reads 420 g and the mass of the water is 400 g thus the weight of a mass of 20 g is also exerted on the scale.
So the aluminium body exerts a force of $F_1 = m \cdot g = 0.2$ N on the support, thus on the water.
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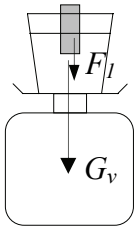

Finding the forces exerted on the aluminium object and stating the condition of equilibrium or the weight of the object:

3 points
(it can be further divided)

The body pulls the spring balance with $F_2 = 0.6$ N thus the weight of the body is $F_1 + F_2 = 0.8$ N. Figure a)

or
The forces exerted on the body are the force exerted by the spring balance, the upthrust of the water and the gravitational force G. $G = F'_1 + F_2'$ Figure b)

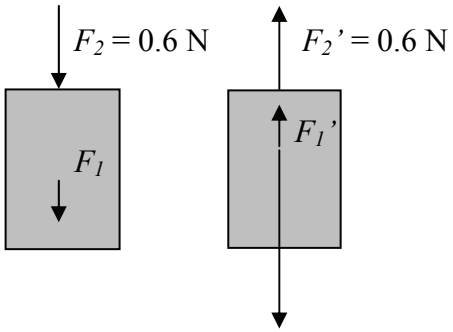

Figure a) *Figure b*)

Finding the mass of the object:

1 point

The mass of the object: $m = \dfrac{G}{g} = 80$ g.

Finding the upthrust:
Reaction of F_1 is F_1', the upthrust exerted by the water: $F_1' = F_1 = 0.2$ N.

2 points

Total **10 points**

Solution 2:

The scale reads 420 g thus the force exerted by the water and the object on the scale is F=4.2 N.
The scale and the spring balance together hold the water and the body with a force of 4.2 N+0.6 N = 4.8 N.

4 points
(it can be further divided)

This force is equal to the weight of an object of mass 480 g. The mass of water is 400 g, thus the mass of the object is 80 g.

2 points
(it can be further divided)

The weight of the object is 0.8 N. The spring balance exerts a force of 0.6 N on the object, thus the water exerts a force of 0.2 N.

3 points
(it can be further divided)

Thus the force exerted by the water is 0.2 N.

1 point

Total **10 points**

Problem 3

a) Recognising the type of process:

1 point

The process is isotherm because the process is slow.
(The point is due without writing this sentence, if the candidate regards the process isotherm during the calculation.)

Applying Boyle's law for the total air column:

pV = constant

1 point

Because the cross section is constant the ratio of the volumes is equal to the ratio of the lengths of the columns.

$l_0 = 10\,\text{cm},\ l = 15\,\text{cm}.$

1 point

$\frac{p}{p_0} = \frac{V_0}{V} = \frac{l_0}{l} = \frac{2}{3}$, thus $p = 0.66 \cdot p_0 = 6.6 \cdot 10^4\,\text{Pa}.$

2 points

b) *Stating the equation for the pressures:*

2 points

$p + \frac{F}{A} = p_0 .$

Calculating the force:

2 points
(it can be further divided)

$A = r^2\pi = 3.14 \cdot 10^{-4}\,\text{m}^2,$
$F = (p_0 - p) \cdot A = 10.4\ \text{N}.$

c) *Applying Boyle's law to the air columns between the two pistons*:

3 points
(it can be further divided)

$\frac{l_1}{l_2} = \frac{V_1}{V_2} = \frac{p}{p_0} = \frac{2}{3},$
From which $l_1 = 4\ \text{cm}.$

Total **12 points**

Problem 4

a) *Stating the work energy theorem for the electric force:*

3 points
(it can be further divided)

The kinetic energy of the electrons is changed because the work is done by the electric field.

$\Delta E_{kin..} = W_{electric}$

$\frac{1}{2}mv^2 - 0 = e \cdot U_1$

Finding the speed:

3 points
(it can be further divided)

$v = \sqrt{\frac{2eU_1}{m}} = 4 \cdot 10^6 \frac{\text{m}}{\text{s}}$.

b) *Examination of the forces exerted on the electrons:*
There is a vertically upward force exerted on the electrons by the electric field,

1 point

the Lorentz force is exerted on the charges which move in magnetic field,

1 point

The electrons move along a straight path if the vector sum of these two forces is zero, thus $\vec{F}_{Lorentz} = -\vec{F}_{electric}$.

1 point

(A correct figure which shows that the forces are balanced is acceptable as well.)

Finding the direction of the magnetic induction:
Vector $\vec{B}$ is perpendicular to the page,

1 point

it points into the paper.

1 point

Calculating the magnetic induction:

$F_{el} = \frac{eU_2}{d}$, where d = 1 cm, U_2 is the voltage between the plates of the condenser,

1 point

$F_L = evB$,

1 point

From the equation of the forces: $F_{el} = F_L$, so $\frac{e \cdot U_2}{d} = evB$, thus $B = 10^{-4}$ T.

2 points
(it can be further divided)

Total **15 points**