Azonosító jel:

ÉRETTSÉGI VIZSGA • 2016. május 17.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

2016. május 17. 8:00

Az írásbeli vizsga időtartama: 240 perc

Pótlapok száma	
Tisztázati	
Piszkozati	

EMBERI ERŐFORRÁSOK MINISZTÉRIUMA

Important information

The time available for the solution of the problems is 240 minutes.

Read the instructions for the problems carefully and use your time wisely.

You may solve the problems in arbitrary order.

Resources that may be used: pocket calculator, data tables

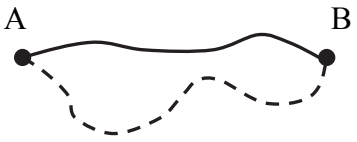
Should the space provided for the solution of a problem be insufficient, ask for an extra sheet.

Please indicate the number of the problem on the extra sheet.

PART ONE

Precisely one of the possible solutions for each of the following questions is correct. Write the letter corresponding to the answer you think is correct in the white square on the right. You may write calculations or draw figures on this problem sheet if necessary.

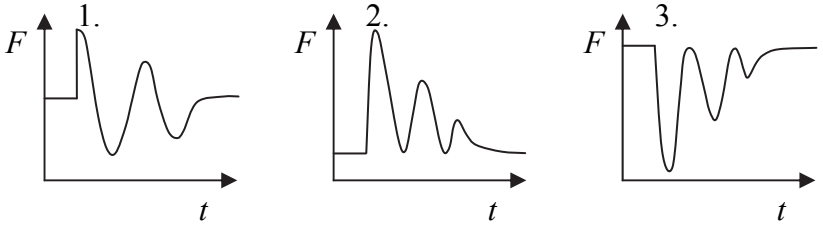
1. Points A and B are connected by a piece of wire with resistance. How does the equivalent resistance between the two points change if we solder another piece of wire, cut from the same type of cable beside the first one?



A) If the second wire is longer than the first one, the equivalent resistance will decrease. If it is shorter, it will increase.
B) If the second wire is longer than the first one, the equivalent resistance will increase. If it is shorter, it will decrease.
C) The equivalent resistance will always increase.
D) The equivalent resistance will always decrease.

2 points	

2. The lid of a box standing on a table suddenly opens and a puppet on a spring pops out, coming to a halt after oscillating vertically. Which diagram depicts the force exerted by the table on the box as a function of time correctly?



A) Figure 1.
B) Figure 2.
C) Figure 3.

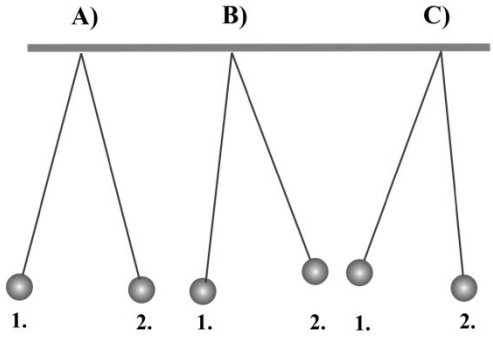
2 points	

3. The wavelike nature of electrons was verified experimentally only long after de Broglie put forward his hypothesis. Which of the following statements about the essence of the experiment is correct?

A) A beam of polarized electrons was produced in the experiment, thereby proving the wavelike nature.
B) Electron interference was produced with two slits in the experiment, thereby proving the wavelike nature.
C) The inverse of the photoelectric effect was produced in the experiment, thereby proving the wavelike nature.

2 points

4. Two balls with equal masses made of insulating material are tied to a point on the ceiling with insulating strings of identical length. We transfer an amount of electric charge Q onto the ball denoted by 1. and an amount of $2Q$ onto the ball denoted by 2. How are the balls located after equilibrium has been reached?



A) As shown in figure A).
B) As shown in figure B).
C) As shown in figure C).

2 points

5. We would like to deploy a spacecraft above a planet such that it hovers constantly above the same spot on the planet, collecting data. What is the condition that allows us to steer the spacecraft onto such a so-called stationary orbit?

A) Such orbits exist only above the Earth's equator.
B) Such orbits exist above any planet.
C) Stationary orbits are possible only above planets that revolve around their axis.
D) Stationary orbits are possible only around planets that possess an atmosphere.

2 points

6. The man in the picture is holding his own spectacles that he wears regularly in front of his eyes. Which statement is true?

A) The man in the picture is farsighted.
B) The man in the picture is short-sighted.
C) We cannot determine the type of the visual fault form the picture.

2 points

7. How should we compress an ideal gas such that its internal energy does not change in the process?

A) We must compress it keeping its pressure constant.
B) We must compress it in an insulated container.
C) We must compress it keeping its temperature constant.
D) It is impossible to compress it this way because we are doing work on it so its energy is bound to increase.

2 points

8. We illuminate a photoelectric cell with a $P = 2$ mW power laser emitting $\lambda = 800$ nm wavelength light and we find that N electrons are ejected from the metal every second. Next, we illuminate the same photoelectric cell with a $P = 4$ mW power laser emitting $\lambda = 400$ nm wavelength light. Approximately how many electrons are ejected per second then?

A) N
B) $2N$
C) $4N$

2 points

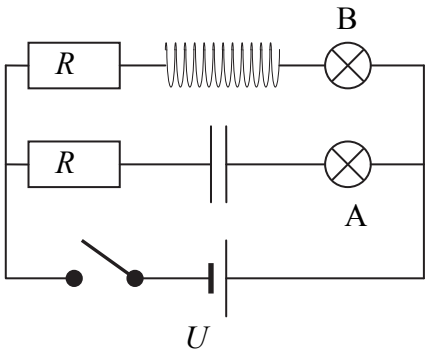
9. A rubber ball is dropped vertically onto the ground from a height of 2 meters. As it bounces on the ground, we measure after each bounce the maximum height it attains before it falls to the ground again. The table below contains the possible heights after the first and second bounces. We know that the same fraction of the ball's mechanical energy is lost during each rebound. Which data pair is correct?

	height after the first bounce	**height after the second bounce**
1.	~ 100 cm	~ 50 cm
2.	~ 100 cm	~ 25 cm
3.	~ 50 cm	~ 25 cm

A) The data pair in the first row.
B) The data pair in the second row.
C) The data pair in the third row.

2 points

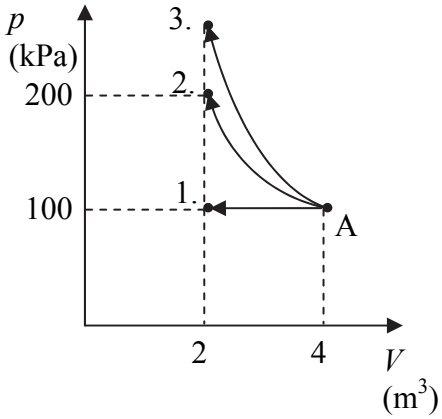
10. We construct a circuit using electric components according to the wiring diagram on the figure. Which of the four possibilities below do we observe when we turn the switch on?



A) Both lamps light up for a short time and then go out.
B) Both lamps will shine permanently.
C) Lamp B will light up for a short time and then go out, while lamp A will start shining slowly and gradually.
D) Lamp A will light up for a short time and then go out, while lamp B will start shining slowly and gradually.

2 points

11. We suddenly compress an ideal gas enclosed in an insulated cylinder to half its original volume. Which arrow depicts this process on the *p – V* graph correctly?



A) Arrow 1.
B) Arrow 2.
C) Arrow 3.

2 points

12. Ultrasound can be used to look for small cracks, faults in various metal objects. This is possible because:

A) Cracks polarize ultrasound, so a detector with a polarizing filter can be used to find the crack.
B) The wavelength of ultrasound is the same order of magnitude as the size of possible cracks, so waves may be reflected or diffracted. Faults can be thus be found.
C) The photons of ultrasound have large energy due to their high frequency, so electrons are ejected from the metal at cracks which can be detected.

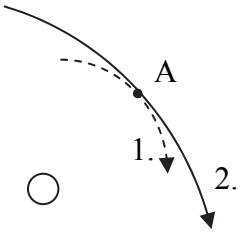
2 points

13. There are approximately 10^7 radioactive nuclei initially in a sample that contains a radioactive isotope. After 3 hours, this number is $7.5 \cdot 10^6$. What is the half-life of the isotope?

A) Less than 6 hours.
B) Exactly 6 hours.
C) More than 6 hours.

2 points

14. Two comets orbit a star along elongated elliptical trajectories. At point "A" they are closest to the star on their trajectories. This point is at the same distance from the star for both comets. The adjacent figure depicts the portion of the two trajectories in this vicinity. Which comet has a greater speed when passing point „A" on its trajectory?



A) Comet 1.
B) Comet 2.
C) Their speed is equal at point „A".
D) It cannot be determined using the information at hand.

2 points

15. We place two solid objects with different temperatures in a calorimeter with negligible heat capacity and seal it. What can we say about the consistency of the materials after thermal equilibrium has been reached?

A) The materials enclosed in the calorimeter can only be solid.
B) One of the materials will definitely be solid, while the other one may be in a solid or a liquid state.
C) Both materials may be in solid state, or one may be in solid, while the other in a liquid state, or possibly both may be in liquid states.
D) One of the materials will definitely be solid, while the other one may be in a solid, a liquid or in a gaseous state.

2 points

PART TWO

Choose one of the three topics below and write a coherent, 1.5-2 page long essay about it. Make sure that the phrasing is accurate and clear, the train of thought is logical and pay attention to the spelling, as this will also affect the evaluation. You do not necessarily have to formulate your thoughts in the exact order of the aspects given. The essay may be written on the following pages.

1. Thermodynamic cycle

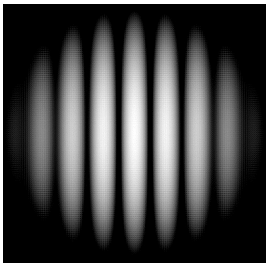
„The goal of Carnot was to analyze the operation of steam engines and other heat engines in general. He clearly saw that while the theory of mechanics was perfectly sufficient to describe the operation of mechanical machines, to explain heat engines, existing theory must be developed further. He set out to calculate the efficiency of engines. Just as his father had calculated the efficiency of water engines from the quantity of the plunging water and its initial and final levels, he tried to determine the efficiency of steam engines from the quantity of heat and the transit of the heat material from a higher to a lower temperature."

Péter Érdi: On the 150th anniversary of the death of Sadi Carnot
Természet Világa, 1982/12.

Sadi Carnot
(1796-1832)

What do we mean by a thermodynamic cycle? Present a specific cycle on a pressure-volume diagram and explain each of the constituent processes. What do we mean by the thermodynamic efficiency of a cycle? Explain the method for determining the efficiency and demonstrate it using the specific example demonstrated on the diagram. Present two practical applications of thermodynamic cycles. Formulate the second law of thermodynamics in the context of thermodynamic cycles. Give another formulation of the second law. Present a process that is not forbidden by the fist law of thermodynamics, but it does not occur in nature in accordance with the second law. Give a detailed analysis of why the process does not contradict the first law but it does the second.

2. Wave optics



"Thomas Young was the first to demonstrate the wavelike nature of light using a very simple experiment in 1803. He directed a narrow light beam which entered between the shutters of a darkened room using mirrors onto the edge of a paper strip cut from a card. The paper strip thus split the beam up, which, rejoining after the strip produced an interference pattern."

based on http://www.cavendishscience.org/phys/tyoung/tyoung.htm

Present the physical quantities that characterize the wave nature of light and determine the relationship between them. What factors affect the color of light? Describe the two-slit interference experiment. Give an explanation for the phenomenon. Let us assume that we performed the experiment with red laser light. How does the interference pattern change if we perform the two-slit interference experiment with green laser light instead of a red one (leaving all other parameters unchanged)? Is it possible to decompose white light into colors using a two-slit experiment? How does the interference pattern change if we vary the distance between the slits? Review the phenomenon of light polarization and mention a practical or natural example.

3. Household electricity

The chief engineer of Ganz and Co. Iron and Machine Works Corporation, Titusz Ottó Bláthy, together with Károly Zipernowsky and Miksa Déri invented the closed iron core transformer capable of energy transfer. The invention was presented at the National Fair in Budapest in 1885. The transformer was first employed in supplying power for the electrical power grid of Rome. The power station was deployed in October 1886.

The first transformer from 1885

Review the properties of the 230 V electrical networks of households. Include the definition of the maximum and effective values of the voltage. What role does the transformer play in supplying electrical power to households? Review an example of transformer usage within the household. How is the electrical network in a household organized? Explain how the electric meter, the circuit breaker and other elements of the network are connected. How does the number of appliances connected to the network influence the current flowing through the electric meter? What is the reason for this? Discuss how the current changes if there is a short-circuit in the network. Explain why a short-circuit is dangerous. What is the role of a circuit breaker in the household? How does the automatic circuit breaker work?

Content	Presentation	Total
18 points	5 points	23 points

PART THREE

Solve the following problems. Justify your statements using calculations, diagrams or explanations, depending on the nature of the questions. Make sure that the notations you use are unambiguous.

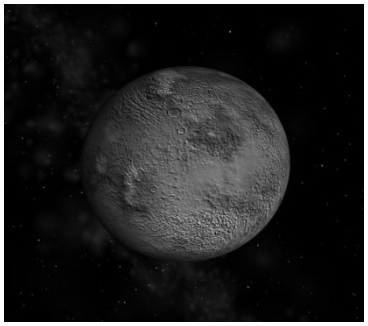
1. The artificial gravitation in a science-fictional interstellar spaceship broke down regularly. When, after fixing the problem the $g = 10\ \mathrm{m/s^2}$ gravitational field customary in the spaceship was "switched on", objects suddenly plunging often broke or caused injuries. (The gravitational field can be assumed to be homogeneous.) So the engineers devised a system which starts up in two phases: for a t_{on} initial duration only a g' reduced effective gravitational field is switched on ($g' < g$). This allows all floating objects to reach the ground gently. After t_{on} the full magnitude of the artificial gravitation becomes effective. According to the new technical specifications, the maximum velocity with which objects may reach the floor during the switching is $v_{max} = 2$ m/s.

a) The extension of the "highest" room of the spaceship in the direction of the artificial gravity is $h = 5$ m. How great should g' and t_{on} be for the system to fulfill the specification? (Let us assume that the collisions between the objects and the floor are perfectly inelastic.)

b) Let us assume, that in one of the rooms a perfectly elastic rubber ball is floating at such height from the smooth, hard floor, that after t_{on} it bounces back precisely to its initial location. (We assume that the values of g' and t_{on} are equal to the ones determined in the previous problem.) With what speed does the ball collide with the floor the next time, i.e. during the second bounce?

a)	b)	Total
7 points	5 points	12 points

2. The smallest dwarf planet, the Ceres was discovered by the Italian astronomer and theologian Giuseppe Piazzi in January 1st, 1801. The distance of the planet from the Sun is about 3 AU.

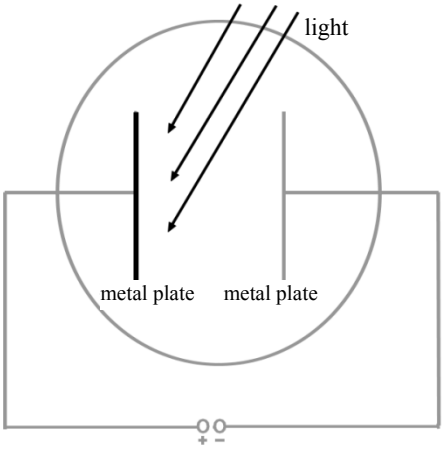


a) What is the orbital period of Ceres?
b) Between what values can the distance from Earth to Ceres vary?
c) How often does Ceres come to its closest distance to Earth?

(1 AU is the average distance between the Earth and the Sun, it is equal to 150 million kilometers to a very good approximation. Let us assume that the orbital planes of Earth and Ceres are the same and that the orbit of Ceres is circular to a good approximation. Ceres and Earth orbit the Sun in the same direction.)

a)	b)	c)	Total
4 points	4 points	4 points	12 points

3. We perform the following experiment in a glass sphere containing vacuum. We illuminate an unknown metal in the sphere with λ = 444 nm wavelength light. The electrons ejected from the metal by the illumination enter the homogeneous electric field between the two metal plates shown in the figure. The electric field strength is *E* = 10 N/C.



a) What is the maximum velocity of the electrons ejected from the illuminated metal plate if they are slowed to a complete halt during a distance of 2.8 cm by the electric field between the metal plates?

b) What is the work function of the unknown metal?

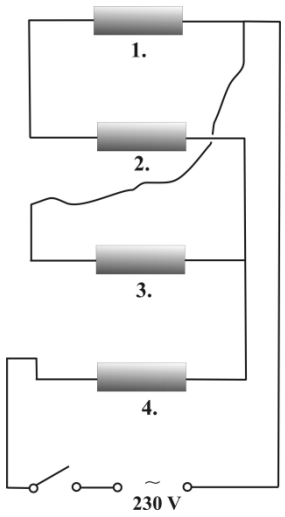
c) The table below contains the work functions of several metals in units of eV. Determine which metal was used in the experiment using the table.

Name of material	cesium	barium	zinc	platinum
work function (eV)	1.94	2.52	4.27	5.36

The mass of the electron is $m_e = 9.1 \cdot 10^{-31}$ kg , its charge is $q = -1.6 \cdot 10^{-19}$ C , the velocity of light is $c = 3 \cdot 10^8 \frac{\text{m}}{\text{s}}$, while Planck's constant is $h = 6.63 \cdot 10^{-34}$ J·s .

a)	b)	c)	Total
5 points	5 points	2 points	12 points

4. In a circuit containing resistors, the wires were soldered together as depicted in the adjacent figure. The resistances of the resistors are equal.



a) Prepare a transparent circuit diagram of the numbered resistors.
b) Determine the equivalent resistance of the resistors in the circuit if the resistance of each one is $R = 100\ \Omega$.
c) What is the effective current on each of the resistors?
d) Rank the numbered resistors according to the power on them. Rank the number of the one with the greatest power first and that of the one with the smallest power last.

The effective voltage in the circuit is 230 V.

a)	b)	c)	d)	Total
3 points	3 points	3 points	2 points	11 points

To be filled out by the examiner evaluating the paper!

	maximum score	score attained
I. Multiple-choice questions	30	
II. Essay: content	18	
II. Essay: presentation	5	
III. Complex problems	47	
Total score for the written exam	**100**	

examiner

Date: .....

	Score attained rounded to the **nearest integer** (elért pontszám **egész számra** kerekítve)	**Integer score** entered in the program (programba beírt **egész** pontszám)
I. Multiple-choice questions (Feleletválasztós kérdéssor)		
II. Essay: content (Esszé: tartalom)		
II. . Essay: presentation (Esszé: kifejtés módja)		
III. Complex problems (Összetett feladatok)		

examiner (javító tanár) notary (jegyző)

Date (Dátum): ..... Date (Dátum): .....