Azonosító jel:

ÉRETTSÉGI VIZSGA • 2022. május 17.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

minden vizsgázó számára

2022. május 17. 8:00

Időtartam: 300 perc

Pótlapok száma	
Tisztázati	
Piszkozati	

EMBERI ERŐFORRÁSOK MINISZTÉRIUMA

Important information

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, you may continue the solution on the empty pages of the examination paper or on auxiliary sheets. Please indicate the number of the problem on the pages.

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. Current *I* is flowing through an uninsulated conductor. How does the current change if we cut the conductor in half, join the pieces side by side and connect them to the voltage generator we used before?

A) The current is reduced to one fourth.
B) The current is reduced by half.
C) The current is doubled.
D) The current is increased four times.

2 points	

2. We would like to double the period of a simple gravity pendulum. How can we do it?

A) We should reduce the mass of the pendulum body by a factor of four.
B) We should increase the length of the pendulum by a factor of four.
C) We should increase the amplitude of the oscillation by a factor of two.
D) We should take the pendulum to a planet where surface gravitation is half of the gravitation on Earth's surface.

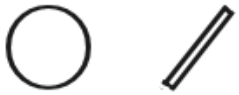
2 points	

3. One day, Jupiter and the full Moon are visible in approximately the same direction in the night sky. What can we say about the distance between Jupiter and Earth? (The trajectories of the planets can be taken to be circles.)

A) The distance is close to maximum.
B) The distance is close to minimum.
C) The question cannot be decided using the information provided.

2 points	

4. A ball and a rod, which is held at an angle, are dropped to the ground from the same height as shown on the figure. They are made of the same material, which makes perfectly elastic collision possible. As they rebound from the ground, the rod starts rotating. The ball bounces back to a greater height. What is the reason for this?



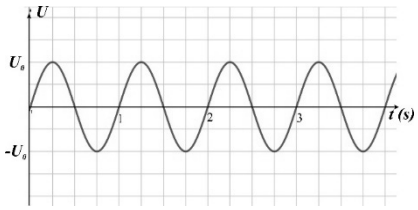
A) Because the rod rotates while going up, its kinetic energy of translation will be smaller and will thus attain a smaller height.

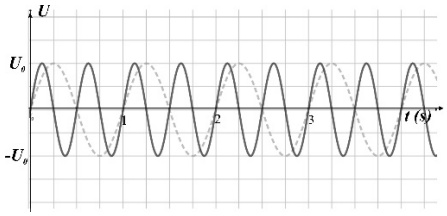
B) Energy conservation will not be fulfilled for the rod because it started rotating.

C) Momentum conservation is not fulfilled for the rod, while it is for the ball. Therefore the ball has a greater kinetic energy and attains a greater height.

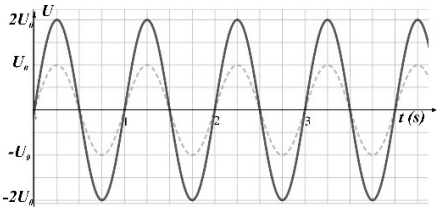
2 points	

5. We rotate a conducting loop in homogeneous magnetic field with constant angular speed ω. The graph shows the voltage induced in the loop as a function of time. How is the graph modified if the loop is rotated with angular speed 2ω, while the magnetic field remains the same?

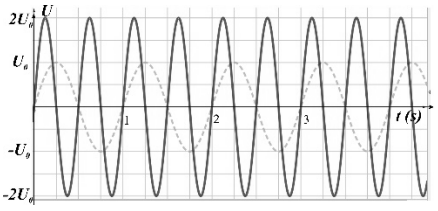




A)



B)



C)

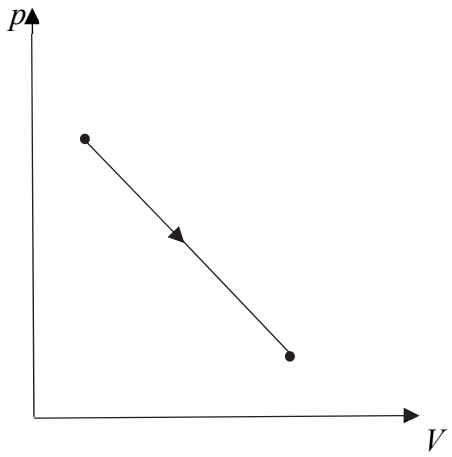
A) It is modified as shown in figure A) .

B) It is modified as shown in figure B) .

C) It is modified as shown in figure C) .

2 points	

6. A constant amount of ideal gas goes through a thermodynamic process characterized by the adjacent *p(V)* graph. The initial and final temperatures are equal. What can we say about the temperature change during the process?



A) The temperature first increases, then decreases during the process.
B) The temperature does not change during the process.
C) The temperature during the process first decreases, then increases.

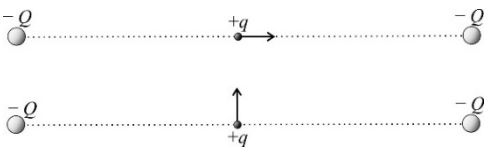
2 points	

7. During the process of annihilation, an electron and a positron collide and are annihilated, giving birth to at least two gamma photons. What is the total energy of the photons, if the two annihilated particles were almost at rest? The masses of the electron and positron are both m_e.

A) $E \sim 2m_ec^2$
B) $E \sim m_ec^2$
C) $E \sim \frac{1}{2}m_ec^2$

2 points	

8. A small positive charge is placed exactly halfway between two fixed, point-like negative charges with equal magnitudes. The small charge is in equilibrium there. How will the small positive charge react if it is displaced slightly along the line connecting the two negative charges and how if it is displaced perpendicular to that?



A) The charge will return to its initial position if it is displaced along the line, but will not return if it is displaced perpendicular to that.
B) The charge will not return to its initial position if it is displaced along the line, but will return if it is displaced perpendicular to that.
C) The charge will not return to its initial position either way.
D) The charge will return to its initial position in both cases.

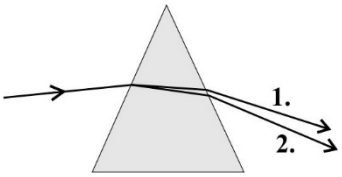
2 points	

9. We store helium gas in one container and neon gas in another. The average kinetic energy of particles in the two containers is equal. What can we say about the temperatures of the gases?

A) The temperature of the helium gas is higher.
B) The temperature of the neon gas is higher.
C) The two temperatures are equal.
D) We cannot tell, using the information given, which gas's temperature is higher.

2 points

10. A ray of composite light is incident upon a glass prism, and is split into two rays after leaving the prism. Which ray traversed the glass with greater speed?



A) Number 1.
B) Number 2.
C) The speeds of the two rays were equal in the glass.

2 points

11. A body starts slipping down a frictionless slope with zero initial velocity. During the first second of its motion, it covers a distance of 20 cm. What distance does it cover during the second second of its motion?

A) 20 cm.
B) 40 cm
C) 60 cm

2 points

12. We consider two planets, whose average densities are equal, but have different radii. Which one has a greater gravitational acceleration on its surface?

A) The planet with a greater radius, because surface gravitational attraction is directly proportional to the planet radius if the average density is a given constant.

B) The planet with a smaller radius, because surface gravitational attraction is inversely proportional to the square of the planet's radius.

C) The surface gravitational accelerations are equal on the two planets with different radii but equal density. ☐

2 points	

13. Our aim is to determine the unknown focal length of a converging lens. Which of the methods listed below can we use?

A) The only correct method is to focus the light from the Sun on a single point on a sheet of paper and then measure the distance between the lens and the paper.

B) The only correct method is to create a sharp image of an object on a screen, then measure the object and image distances and use them to compute the focal length.

C) Both of the methods above can be used to determine the focal length.

D) Neither one of the methods above can be used to determine the focal length. ☐

2 points	

14. Gravitational acceleration on the surface of the Moon is about one sixths of that on Earth's surface. We launch two projectiles horizontally from equal heights and with equal initial speeds. One is launched on Earth, the other on the Moon, both at level ground. How far does the projectile travel on the Moon, if it travels 60 m on Earth? (Air drag can be neglected.)

A) ~ 10 m-re.

B) ~ 60 m-re.

C) ~ 360 m-re.

D) ~ 147 m-re ☐

2 points	

15. An ice cube is floating in a glass of drink. How does the level of the liquid change in the glass, if the ice cube melts? The density of the drink is 0,95 g/cm^3.

A) The level of the liquid increases.
B) The level of the liquid decreases.
C) The level of the liquid does not change.

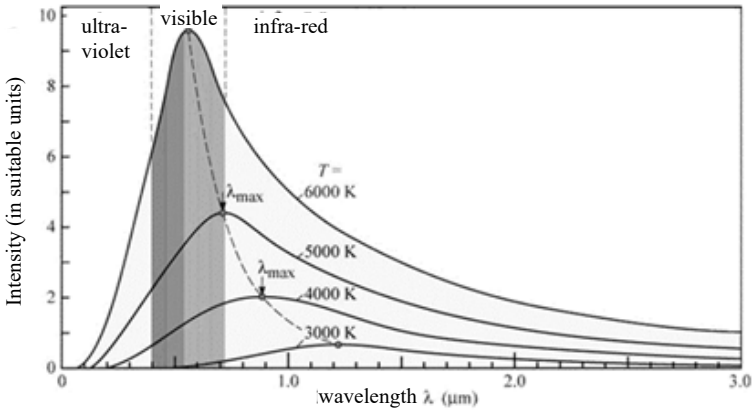
2 points	

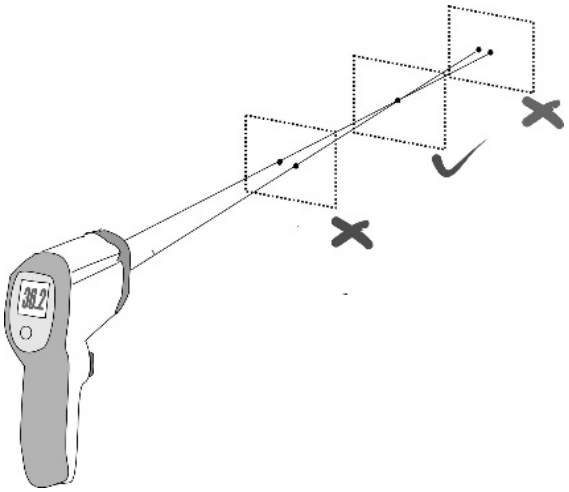
PART TWO

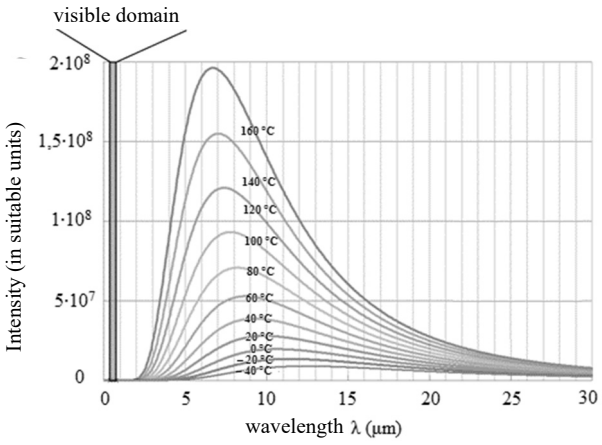
Choose one of the three topics below and write a coherent, 1.5-2 page long essay about it. Make sure that the phrasing is accurate and clear, the train of thought is logical and pay attention to the spelling, as this will also affect the evaluation. You do not necessarily have to formulate your thoughts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

1. Contactless thermometer

Contactless thermometers have grown popular lately. These thermometers detect the electromagnetic waves emitted by bodies and use that to determine the surface temperature of the body. Every body emits electromagnetic waves. The intensity and wavelength distribution depends on the temperature of the body. The color and surface quality of the body may also influence the radiation emitted, so measurements are calibrated for mat black surfaces. The graphs below show the radiation intensity emitted by bodies with different temperatures as a function of the radiation wavelength. The sensors of the thermometers convert radiation to an electric signal. The magnitude of the signal depends on the incident radiation intensity, so the device can determine the temperature from the magnitude of the electric signal. The measurement will be accurate if the body is at a well defined distance from the thermometer as the radiation intensity decreases with increasing distance. Setting the proper distance is sometimes facilitated by two laser beams. These are built into the device such that they are not parallel, but are converging slightly. When the two laser spots are coincident, the distance is just right for the measurement. This is the reason for the false belief that these are "laser thermometers" that determine the temperature of the body using the reflected laser light.



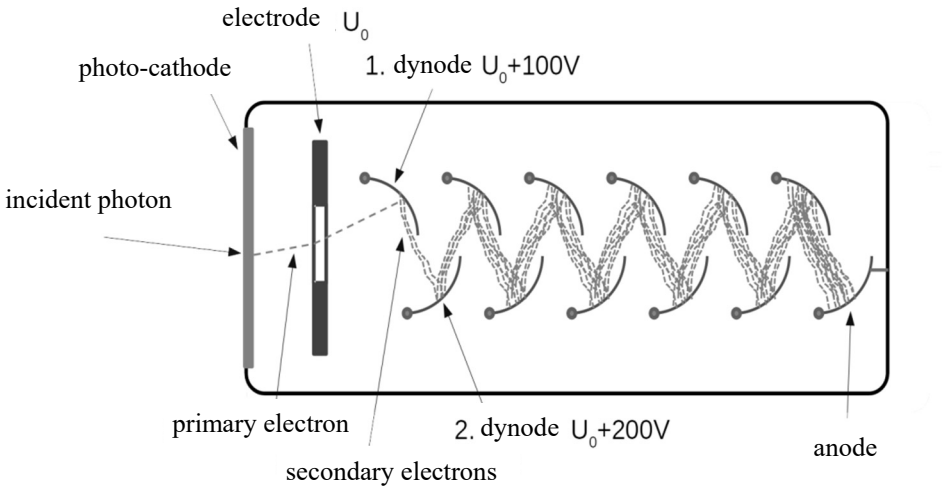




a) What wavelength domains is the electromagnetic spectrum divided into? Review the main domains in the order of decreasing wavelength.
b) Analyze the graphs (not quantitatively, only naming trends): how does the overall intensity of the electromagnetic radiation emitted by the bodies and its spectral distribution change as the temperature changes?
c) Determine using the graphs the domain of the electromagnetic spectrum where the radiation emitted by the human body has its maximum intensity.
d) Where do infra-red rays appear in our environment? Where do we utilize them? Mention three examples other than contactless thermometers, discussing the role of infra-red radiation in each case.
e) How do the two laser beams aid in correct positioning? Why do we use laser light, why is it more suitable than the light of a regular torch?

2. The photoelectron-multiplier

The "photoelectron-multiplier tube" is an experimental device that is a very sensitive detector of light. Even a single photon, a single quantum of light can be detected. At the head of the tube there is the photo-cathode, from which the photons of the incident light eject electrons. In the vacuum tube behind the cathode these electrons are directed by the electric field of an electrode onto the series of so-called dynodes. Each of the dynodes is held at a potential about 100 Volts higher than the preceding one. The so-called primary electron from the cathode that is incident on the first dynode which is at a potential 100 V higher, will eject about 10 so-called secondary electrons. These, accelerating towards the second dynode will also eject about 10 electrons each. Thus even a single photo-electron will result in a sizable amount of charge reaching the anode at the end of the device. The current pulse generated this way can easily be measured.



a) What is the photoelectric effect? What determines whether an electron is emitted by the metal in a given case? If so, what does the maximum energy of the emitted electron depend on and how large can it be?
b) How does an electron acquire the energy to eject about 10 others from the next dynode?
c) What energy will the electron ejected from the photo-cathode with a kinetic energy of 1 eV have upon reaching the first dynode?
d) How many dynodes should we assemble in a row (including the last, the anode), if we would like a single photon to to result in a charge of 1.6 pC created on the anode? (The elementary charge is $e = 1{,}6 \cdot 10^{-19}$ C.)

3. Nuclear fission

After the discovery of fission (1939), and the demonstration of self-sustaining chain-reaction (1942) nuclear energy was used for military purposes. A substantial amount of electric energy (250 kW) was generated only in 1951 – the halls of the EBR (Experimental Breed Reactor) were lit with the electricity produced (Arco, USA). The first nuclear power plant connected to the electric grid was operated in the Soviet Union in 1954, delivering an electric power of 5000 kW. An industrial plant with sizable power (60 MW) began operation in 1956 in Calder Hall.

Simonyi Károly: The cultural history of physics

a) Review the process of nuclear fission.
b) The uranium nucleus with mass-number 235 is capable of spontaneous fission as well as radioactive α-decay. What is the difference between the two processes?
c) We detect the spontaneous fission of ^{235}U billions of times more rarely than we do its α-decay. Which process has a greater activation energy and which one releases more energy?
d) How is the probability of spontaneous fission (activation energy) of the ^{235}U nucleus changed by neutron capture?
e) Compare the proton to neutron ratio in nuclei capable of nuclear fission with that in the nuclei of stable decay products which result in the process.
f) Review the process of chain reaction based on nuclear fission.
g) Explain the concept of multiplication factor.
h) Explain the connection between the multiplication factor and the time dependence of chain reaction.
i) How can the multiplication factor of the chain reaction be kept at the desired value in nuclear reactors?
j) Name the Hungarian scientist in the picture, who discovered the possibility of thermonuclear chain reaction.

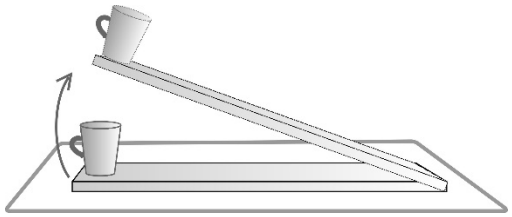
Content	Presentation	Total
18 points	5 points	23 points

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.

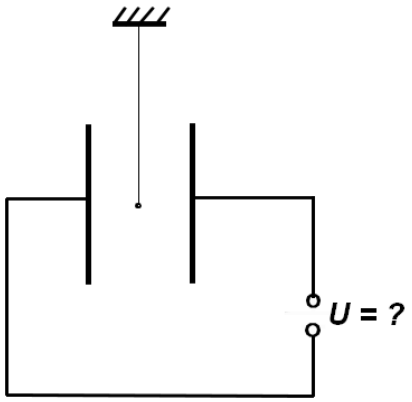
1. We would like to determine the coefficient of static friction and kinetic (sliding) friction between a plank used for shelves and a mug. We place the plank on level ground and place the mug at one of its ends. We start lifting the end of the plank as shown in the figure and we observe that when the plank encloses a 28º angle with the horizontal, the mug starts slipping and covers a distance of 2.5 meters in 4 seconds.

What are the values for the coefficients of static and kinetic friction in question? (g = 9.8 m/s^2)



Total
14 points

2. We hang a point-like metal ball with mass m = 2 g, having no electric charge initially on an l = 25 cm long insulating string and lower it between the plates of a parallel plate capacitor as shown in the figure. The distance of the plates is d = 10 cm, the ball is located halfway between them initially. The capacitor is not charged at first. The small ball is then supplied with an electric charge of Q = -1 nC.



We start increasing *slowly* the voltage between the initially uncharged capacitor plates. At what value of the voltage will the ball touch one of the plates? (g = 9.8 m/s^2)

Total
11 points

3. The water vapor density of the atmosphere at a given area is 12.8 g/cm³ at a temperature of 25 °C. The table below contains the density of saturated water vapor (vapor equilibrium density) as a function of temperature.

T (°C)	ρ (g/m³)	T (°C)	ρ (g/m³)	T (°C)	ρ (g/m³)
1	5.2	11	10.0	21	18.3
2	5.6	12	10.7	22	19.4
3	6.0	13	11.4	23	20.6
4	6.4	14	12.1	24	21.8
5	6.8	15	12.8	25	23.0
6	7.3	16	13.6	26	24.4
7	7.8	17	14.5	27	25.8
8	8.3	18	15.4	28	27.2
9	8.8	19	16.3	29	28.7
10	9.4	20	17.3	30	30.3

a) What is the value of the relative humidity?
b) What is the temperature of the dew point?
c) How many grams of vapor condense as fog or on a surface above a 1 m² area of the ground, if the temperature decreases to 5 °C and the layer of air filled with vapor is 200 m high?
d) Calculate the pressure of water vapor at a temperature of 5 °C. We may assume water vapor to be an ideal gas for our calculation. Use the data from the table for the calculation and the fact that the molar mass of water is 18 g/mol.

a)	b)	c)	d)	Total
4 points	2 points	3 points	3 points	12 points

4. Modern pulsed lasers can generate light with extreme high, 10^{18} - 10^{20} W/cm^2 intensities for a very short duration. The diameter of the largest concave spherical mirror in the world is 500 m (FAST telescope). We could use this to focus the rays of the Sun onto a circular area with a diameter of 1.2 meters.

a) What is the intensity of sunlight that reaches Earth's surface?
b) What is the ratio between the intensity of sunlight on the circular area in the focus of the spherical mirror and the intensity of the pulsed lasers? (The optical axis of the spherical mirror is parallel to the direction of light rays.)

The power radiated by the Sun is $3.86 \cdot 10^{26}$ Watts, the Earth-Sun distance is 150 000 000 km, the ratio of the radiation that reaches Earth's surface through the atmosphere is 81 %.

a)	b)	Total
5 points	5 points	10 points

	score	
	maximum	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**	

date

examiner

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	pontszáma **egész számra** kerekítve	
	elért	programba beírt
I. Feleletválasztós kérdéssor		
II. Témakifejtés: tartalom		
II. Témakifejtés: kifejtés módja		
III. Összetett feladatok		

dátum

dátum

javító tanár

jegyző