Azonosító jel:

ÉRETTSÉGI VIZSGA • 2024. május 22.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

2024. május 22. 8:00

Időtartam: 300 perc

Pótlapok száma	
Tisztázati	
Piszkozati	

OKTATÁSI HIVATAL

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.

Sources not indicated on the problem sheet can be found in the evaluation guide.

PART ONE

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

1. A pebble is thrown vertically upward and it reaches the turning point at the top of its trajectory after 2 seconds. Counting from the time of the throw, when is the pebble halfway to its maximum height in the upward phase of its motion? (Air drag is negligible.)

A) Before 0.5 seconds.
B) At 0.5 seconds.
C) Between 0.5 seconds and 1 second.
D) At 1 second.

2 points	

2. What can we state about the Geiger–Müller counter (G–M counter)?

A) There is vacuum inside the G–M counter.
B) There is usually some noble gas with additives inside the G–M counter.
C) The G–M counter does not require an electric voltage to work.

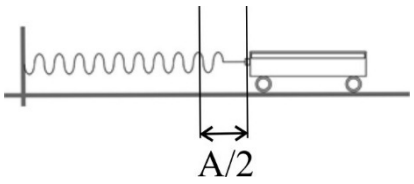
2 points	

3. What would be the surface gravitational acceleration on the surface of a planet with the same density as the Earth, but twice the diameter of the Earth, compared to Earth's gravitational acceleration *g*?

A) $2\,g$
B) $4\,g$
C) g

2 points	

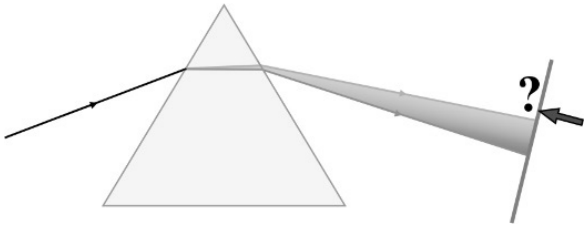
4. We attached a small car to a horizontal spring and made it start oscillating on a horizontal table. What can we say about the system when the displacement of the car is precisely half the amplitude?



A) The velocity of the car is half the maximum velocity.
B) The acceleration of the car is half the maximum acceleration.
C) The kinetic energy of the car is half the maximum kinetic energy.
D) The elastic energy of the spring is half the maximum elastic energy.

2 points	

5. A narrow beam of solar radiation is passed through a prism and projected onto a screen. What kind of radiation impinges on the screen at the point marked with the arrow? (Let us assume that the prism is transparent for all components of the solar radiation.)



A) Violet light, but much dimmer than the one visible in the primary rainbow.
B) Infrared radiation, which is invisible to the human eye.
C) Nothing, the components of the solar radiation reach the screen at a slightly lower position.

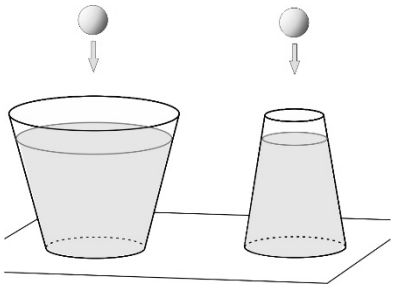
2 points	

6. Which of the following quantities can be determined from the average kinetic energy of the molecules of a gas, if no other data is available?

A) The pressure of the gas.
B) The volume of the gas.
C) The internal energy of the gas.
D) The temperature of the gas.

2 points	

7. Two containers with the same area of their base but of different shapes are filled with water up to the same height. We place a 2 cm^3 volume steel ball at the bottom of both containers. Which of the bottom surfaces of the containers in contact with the water is then subjected to a greater compressive force?



A) The narrowing container, because the water level rises more inside it.
B) The widening container, because the water displaced by the ball also presses against the container wall.
C) The compressive forces are equal, because it was equal before we placed the balls in and we placed two identical balls into the containers. ☐

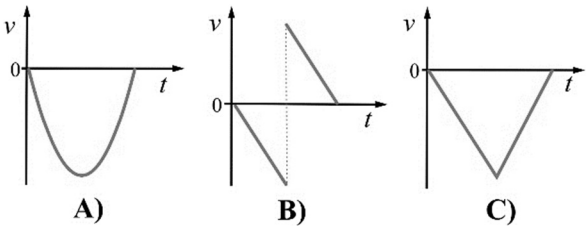
2 points	

8. What does the capacity of a capacitor tell us?

A) The maximum amount of electric charge that the capacitor can store.
B) The maximum amount of energy that the electric field built up in the capacitor can store.
C) The amount of charge stored per unit voltage. ☐

2 points	

9. A rubber ball is dropped and it bounces back perfectly elastically from the hard, smooth floor. Which of the adjacent graphs depicts the velocity of the ball as a function of time correctly? We observe the motion of the ball until it reaches its initial position and the upward velocity direction is positive.



A) Graph A).
B) Graph B).
C) Graph C).
D) Neither one of the graphs is correct. ☐

2 points	

10. How does the presence of moderator material affect the multiplication factor of fission processes in a nuclear power plant?

A) It decreases the multiplication factor.
B) It does not affect the multiplication factor.
C) It increases the multiplication factor.

2 points	

11. 50% of the volume of a metal foam with holes is the air trapped in the holes. The temperature of a brick made of metal foam gradually increases significantly. How does its density change during this process?

A) The density of the brick increases.
B) The density of the brick does not change.
C) The density of the brick decreases.

2 points	

12. A $^{4}_{2}\mathrm{He}^{2+}$ and a $^{6}_{3}\mathrm{Li}^{3+}$ ion, i.e. two atomic nuclei which repel one another are placed 1 mm from each other in vacuum. Which will accelerate more? (All other forces on the atomic nuclei are negligible.)

A) The helium nucleus ($^{4}_{2}\mathrm{He}^{2+}$).
B) The lithium nucleus ($^{6}_{3}\mathrm{Li}^{3+}$).
C) The nuclei move with accelerations of equal magnitude.

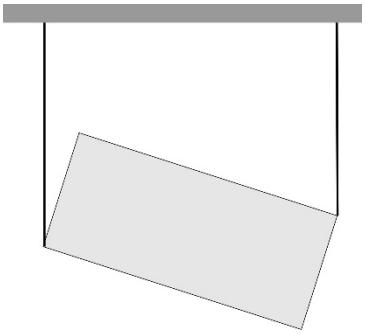
2 points	

13. Which statement concerning negative diopter glass lenses placed in air is correct?

A) They have focal points only on one side.
B) They can be made with one surface of the lens flat and the other concave when viewed from the outside.
C) They can be made only such that both surfaces of the lens are concave when viewed from the outside.

2 points

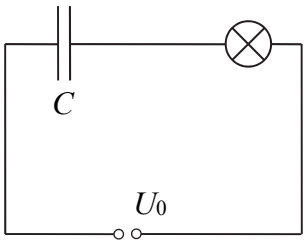
14. We fix a rectangular plate with homogeneous mass distribution using two thin vertical rods as depicted in the figure. The supporting rod is fixed to the lower corner on one side and to the upper corner on the other side. In which of the rods arises a greater force if the plate is at rest and only the gravitational force is acting on it apart from the forces of the rods?



A) In the one fixed to the lower corner (on the left side).
B) In the one fixed to the upper corner (right side).
C) Forces of equal magnitude arise in the two rods.

2 points

15. A light-bulb is connected in series with a capacitor in a circuit as shown on the diagram. How can we make the light-bulb shine continuously?



A) Only by applying DC voltage with the right magnitude to the circuit.
B) Only by applying AC voltage with the right magnitude and frequency to the circuit.
C) The light-bulb can shine continuously with either a DC voltage or an AC voltage.
D) The light-bulb will not shine continuously neither with a DC nor with an AC voltage.

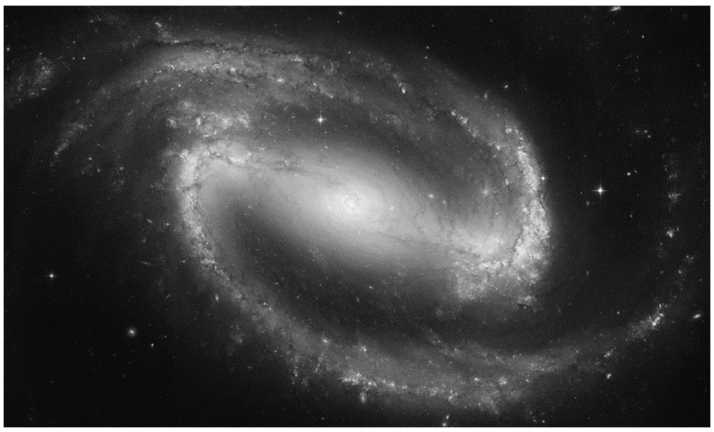
2 points

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. Hubble's law

In the 1920s, the American astronomer Edwin Hubble investigated the light from Cepheid-type pulsating variable stars and could determine their distance from Earth. It turned out that the spiral nebulae containing these stars are located outside the Milky Way – we now know that they are distant galaxies. He compared the distance data with the spectra of the galaxies' light and found that the more distant the object, the more the wavelength of the galaxy's light is shifted towards the red. He explained the observed redshift by assuming that distant galaxies are moving away from us at high speeds, and their light appears redshifted because of the Doppler-effect. According to Hubble's law, the redshift, and hence the speed v with which the distance grows, is proportional to the distance D from us: $v = H \cdot D$, where H is the so-called Hubble's constant, about 22.7 km/s/million light years according to our measurements today. Hubble's discovery thus provided the first evidence of the continuing expansion of the universe and laid the foundations for the Big Bang theory.



a) Describe the basic quantities that characterize waves and the relationship between them.
b) Describe qualitatively, using a diagram, the Doppler phenomenon for a moving wave source. What causes the decrease or increase of the observed wavelength?
c) How does the frequency of the waves we detect change for a moving wave source?
d) Give an example of the Doppler phenomenon in everyday life.
e) Is Hubble's law valid for the planets of our Solar System or the stars closest to us? Justify your answer.
f) Explain how the Hubble's law supports the Big Bang theory.
g) The galaxy NGC 1300 that is visible on the picture is about 61 million light years away. With approximately what speed is it moving away from us?

2. ITER

„ITER (International Thermonuclear Experimental Reactor) is an international [fusion energy] research and development project, with the aim of developing the technology for future electric power plants […].

[…] According to plans ITER will [in one operational stage] be able to maintain 500 MW fusion power for at most 400 seconds […]. During this time, about half a gram of deuterium-tritium mixture will fuse in the 840 m³ volume reactor chamber.

Although ITER will be able to produce fusion energy, this will not be used to generate electricity, but rather to [explore] the feasibility of fusion energy. […]

When a deuterium and a tritium nuclei fuse, a helium nucleus (alpha-particle) and a high energy neutron are released, [in the course of which 17.6 MeV of energy is released].”

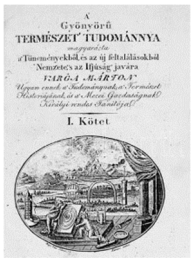
a) Review the concept of nucleons, their types and the properties of nuclear interaction.
b) Describe the phenomenon of nuclear fusion. For which nuclei is nuclear fusion accompanied by energy release?
c) Where does nuclear fusion play a dominant role in nature?
d) What circumstances are necessary for nuclear fusion to take place in nature? Why are these difficult to realize with technology? Give at least one reason.
e) Write the reaction equation for the nuclear process that takes place in ITER. Indicate mass and atomic numbers as well.
f) Approximately what is the mass of the deuterium and tritium in the mixture that is used during one stage of operation?
g) Approximately how many deuterium and tritium nuclei fuse during one stage of operation?

(The masses of the proton and the neutron are approximately $1.67 \cdot 10^{-27}$ kg.)

3. Motion in a gravitational field

The direction of earthly gravitation – if it is not hindered – is always in a straight line. If there is a smooth plane which is parallel to Earth's surface, it is perpendicular to it. It is thus vertical.

Varga Márton: The science of beautiful nature, Nagyvárad, 1808.



a) Write down the general law of gravitation and explain the physical quantities in it.
b) Explain how the gravitational acceleration measurable on Earth's surface can be calculated using the properties of planet Earth.
c) Describe the equations that characterize the speed and displacement during free-fall in the vicinity of Earth's surface. (Air drag is negligible.)
d) Give and interpret the relationships describing the velocity and displacement of an object thrown vertically upward with initial velocity v_0 from the moment the body is thrown up to the moment it returns.
e) Plot the acceleration–time graph of the vertical throw.
f) Give the definition of the first and second cosmic velocities.
g) Compare the International Space Station's velocity with the first cosmic velocity, explaining an eventual equality or difference.
h) What do we mean by weightlessness? Why is there weightlessness on the International Space Station?
i) Give a general discussion about the stages of an interplanetary journey at which astronauts would be in a state of weightlessness. Justify your statements.

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. A power plant produces electricity for a distant town with a constant output of 10 MW. The power is transmitted to a transformer station on the outskirts of the town via a high-voltage transmission line. The resistance of the transmission line is 10 Ohm.

a) Determine the current flowing through the transmission line and calculate the electrical power loss on the transmission line and the power consumed by the city if the transmission line voltage is
25 kV.

b) Calculate the electrical power loss on the transmission line and the power consumed by the city if the transmission line voltage is
100 kV.

a)	b)	Total
5 points	5 points	10 points

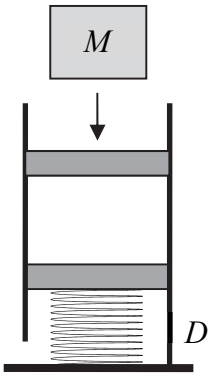
2. A projectile with 250 m/s velocity and 2 g mass penetrates a 0.5 kg mass wooden slab and remains in it. The slab is standing on a horizontal surface, the velocity of the projectile just before the impact is parallel with the surface. The wooden slab starts moving as a consequence of the impact and stops after sliding a distance of 1 meter.

What is the coefficient of friction between the slab and the surface?

(Consider the collision as instantaneous, the displacement of the wooden slab during the collision is negligible. $g = 9.8\ m/s^2$)

Total
12 points

3. Inside a vertical cylinder with cross-section $A = 10\ \text{cm}^2$, two pistons that can be considered weightless and to move without friction seal air with $V_0 = 100\ \text{cm}^3$ and $T_0 = 20\ °\text{C}$. The lower piston is supported by a spring with spring constant $D = 10\ \text{N/cm}$ that is fixed to the bottom of the cylinder. Atmospheric pressure is 10^5 Pa, the lower part of the cylinder (where the spring resides) is open on the side. We slowly, carefully place a stone with mass $M = 2$ kg onto the upper piston.



a) By what amount does the upper piston sink because of the load, if we can consider the temperature of the air to be constant during the entire process?

b) By what amount do we need to raise the temperature of the air after this, if we want the upper piston to return to its original height together with the load?
($g = 9.8\ \text{m/s}^2$)

a)	b)	Total
8 points	5 points	13 points

4. Deuterium is the isotope of hydrogen with mass number 2. A deuterium nucleus can be split by a gamma-photon of sufficiently high energy to release a proton and a neutron.

What is the minimum frequency of the photon that can split a deuterium nucleus in two?

The mass of the neutron: $1.6749 \cdot 10^{-27}$ kg, the mass of the proton: $1.6726 \cdot 10^{-27}$ kg, the mass of the deuterium nucleus: $3.3436 \cdot 10^{-27}$ kg, Planck's constant: $h = 6.63 \cdot 10^{-34}$ Js, the velocity of light in vacuum: $c = 3 \cdot 10^{8}$ m/s.

Total
12 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

---

	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