Azonosító jel:

ÉRETTSÉGI VIZSGA • 2025. május 20.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

2025. május 20. 8:00

Időtartam: 300 perc

Pótlapok száma	
Tisztázati	
Piszkozati	

OKTATÁSI HIVATAL

Important information

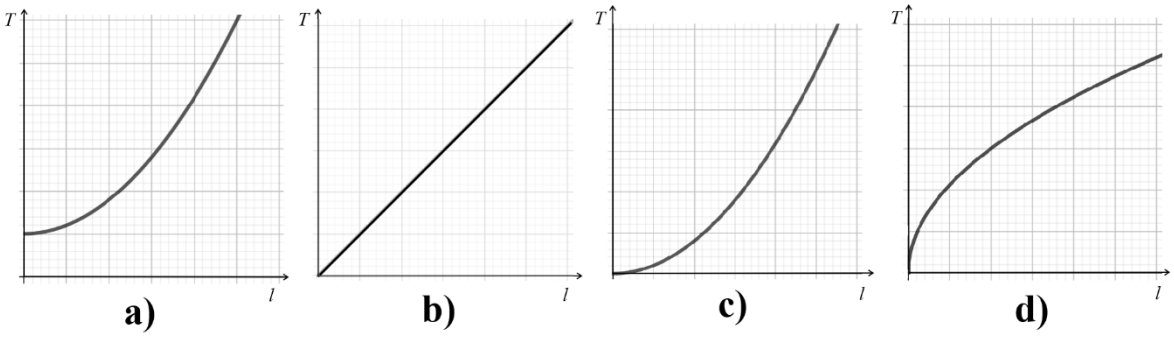
Read the instructions for the problems carefully and use your time wisely.
You may solve the problems in arbitrary order.
Resources that may be used: pocket calculator, data tables
Should the space provided for the solution of a problem be insufficient, you may continue the solution on the empty pages 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 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.)

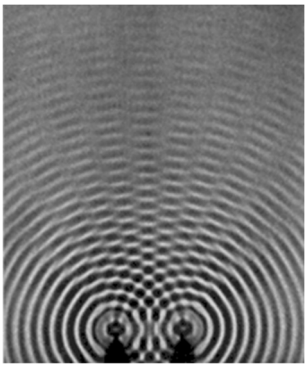
1. Which one of the graphs below depicts correctly the functional dependence of a pendulum's time period *T* on its length *l*?



A) Graph a).
B) Graph b).
C) Graph c).
D) Graph d).

2 points	

2. The picture depicts surface waves in a tub of water, driven by two oscillating point-like sources. What phenomenon is visible on the picture?



A) Deflection
B) Interference
C) Diffraction

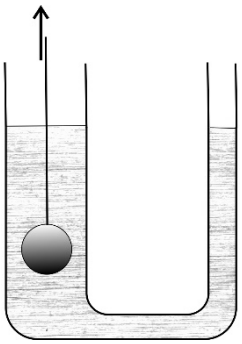
2 points	

3. An object moves along two consecutive sections of a straight path with a constant speed on each section – but the two speeds are different. Under what condition is the overall average speed of the object on the two sections equal to the arithmetic mean of the two speeds?

A) Only if the two sections of the path are equal in length.
B) Only if the object covers the two sections of the path in equal time intervals.
C) Both of the above conditions are sufficient.
D) Neither of the above conditions is sufficient.

2 points

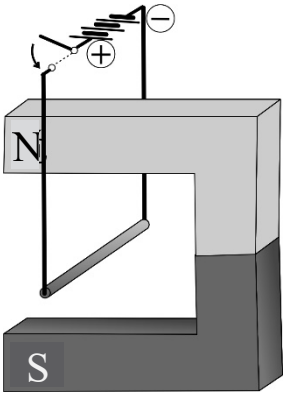
4. The vessel with two branches depicted on the picture contains water. We hang an iron sphere on a string into the water in the wider branch. How does the water level in the narrower branch change when we pull the object out of the water?



A) It increases.
B) It remains unchanged.
C) It decreases.

2 points

5. In which direction will the wire hanging between the two poles of the horseshoe magnet move when the switch is turned on?



A) The wire will move outward from between the poles (left on the figure).
B) The wire will move inward between the poles (right on the figure).
C) It is impossible to tell from the picture the direction of the wire's motion.

2 points

6. An article about the tracks built for high speed trains in a newspaper reads: "Speed affects the layout of the railroad line as well. For a train to follow the turning track safely at 360 km/h, the radius of the track curve must be much larger (5400 m) than at 120 km/h." What can the radius of the track curve be, if the highest allowed speed for the trains is only 120 km/h? (All other properties of the tracks are identical.)

A) 600 m
B) 1800 m
C) 2700 m
D) 3600 m

2 points	

7. There are two types of radioactive isotopes in a laboratory. The initial quantities and half-lives can be seen in the table below. After what time will the quantities of the two isotopes be approximately equal?

	quantity	**half-life**
first isotope	160 moles	1 day
second isotope	20 moles	2 days

A) After 2 days.
B) After 4 days.
C) After 6 days.
D) After 8 days.

2 points	

8. Three charged objects are in equilibrium, placed along a straight line on a table with no friction. The charges of the two outside objects are positive, that of the middle one is negative. What happens if we move the rightmost object with positive charge along the straight line of the objects to the right?

A) Both the middle and leftmost charged objects will also start moving right.
B) The middle one starts moving right, the leftmost one will start moving left.
C) The middle one starts moving left, the leftmost one will start moving right.
D) Both charged objects will start moving left.

2 points	

9. A hollow sphere with finite mass is in free-fall towards the ground. Inside it, there is a small ball with finite mass. Where is the ball located inside the hollow sphere during the fall if air drag is <u>not</u> negligible?

A) It is located on the bottom of the hollow sphere.
B) It may be located anywhere as it is floating.
C) It is located at the top of the hollow sphere.

2 points

10. The dew-point on Monday was at 12 °C, on Tuesday it was at 14 °C according to the diary of an amateur observer. Is that possible?

A) No, because the dew-point is a physical constant, which is different for different liquids.
B) Yes, if the difference between the daily maximum temperatures was 2 °C as well.
C) No, because the dew-point of water is always below 10 °C.
D) Yes, if the absolute humidity was different on the two days of the week.

2 points

11. An ultraviolet and an infrared light-ray are propagating side-by-side in glass, parallel with each other. When they reach the planar interface between the glass and the outside air, the ultraviolet ray suffers total reflection, while part of the infrared light is transmitted into the air. For which light is the refractive index of the glass greater?

A) For the ultraviolet light.
B) For the infrared light.
D) The refractive index is the same for the two lights.

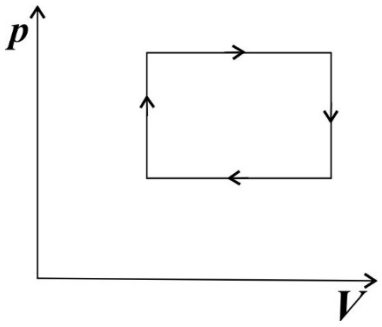
2 points

12. We have two particles with different masses, but equal velocities. Which one has a greater de-Broglie wavelength?

A) The one that has a greater mass.
B) The one that has a smaller mass.
C) Their de-Broglie wavelengths are equal, because their velocities are equal.
D) It depends on whether the particles are elementary particles (e.g. electron) or composite particles (e.g. alpha particle).

2 points

13. A heat engine undergoes the cyclic process depicted on the graph. After a while, we double the number of cycles per unit time. What can we say about the functioning of the heat engine afterwards?



A) The heat engine's efficiency is doubled, its useful power does not change.
B) The heat engine's useful power is doubled, its efficiency does not change.
C) Both the useful power and the efficiency of the heat engine are doubled.
D) Neither of the above statements are true.

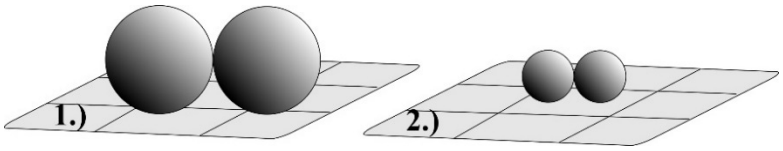
2 points	

14. The current flowing in the filament of traditional incandescent light-bulbs that were in domestic use in the past is greater just after being switched on than during continuous operation. What is the reason for this?

A) The temperature of the filament is lower just after being switched on, so its resistance is smaller.
B) The temperature of the filament is lower just after being switched on, so its resistance is greater.
C) The temperature of the filament is lower just after being switched on, so the voltage drop on it is smaller than during continuous operation.

2 points	

15. We have two pairs of balls made of the same material, with homogeneous mass distribution. The two members of each pair have equal sizes and are placed directly adjacent of each other. The diameter of the larger balls is twice the diameter of the smaller ones. How many times is the attractive force greater between the larger balls, than between the smaller balls?



A) 2 times.
B) 4 times.
C) 8 times.
D) 16 times.

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. Free diving

At the end of November 2020, a 27 year old Hungarian girl, Fatima Korok took a deep breath, swam 86 meters down to the depths of the Red Sea and returned back to the surface with the same breath. Some excerpts are cited below from the athlete's account:
[…] I finish taking in air. I turn on my belly, dive down with my head and upper body […] I begin my descent to the deep. During the first ten meters, which I cover in about ten seconds, I have to fight the buoyancy force of water. This is one of the most tiring stages […] at a depth of 40-45 meters I am heavier than the water surrounding my body, so buoyancy ceases. I no longer paddle with my feet, I am being pulled down by the depths. […] I begin falling […] The size of the lung – like that of a plastic ball – is known at the surface, but it reduces by half due to the pressure at a depth of 10 meters, at twenty meters it is reduced to a third and so on, until it attains its smallest possible value. Down in the deep it is half the size of your fist […] While falling […] I take care to hold an optimal position […] When I turn and start paddling upwards the real work begins […] On the last 25 meters I use physics in the opposite sense: the buoyancy force of water, which was an obstacle during descent, now helps my progress. As my lung continuously expands again, that too helps my ascent […]

a) What are the forces that act upon an object (at rest) submerged in a liquid? What is the condition for a submerged object to rise to the surface?
b) What does the hydro-static pressure experienced in water depend on?
c) What happens to the volume of gases and liquids if their pressure increases (at a given constant temperature)?
d) Analyze the forces acting on the athlete during the dive. Which of the forces changes with the depth, in what way does it change and what is the cause of this variation?
e) Is the statement underlined in the text correct from the viewpoint of physics? If not, how could it be corrected?
f) During which stages of the dive must the athlete paddle herself with force to move in the desired direction and why?
g) What would be the volume of air, which is 5 liters at a pressure 10^5 Pa, at a pressure equal to that found 86 meters under water if we can assume the temperature to be constant?

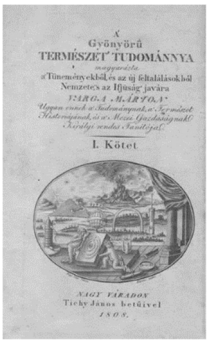
2. The nuclear clock

Of the clocks used today, atomic clocks are the most accurate. The type of atomic clock used most widely, the one associated with the definition of the second, is the cesium atomic clock. This type uses the time period belonging to the electron transition between two very close (hyperfine) energy levels of the cesium atom to measure time. The transition can be initiated by exciting the outermost electron of the cesium atom with microwave radiation. The second is defined as 9 192 631 770 times the oscillation period of the photon emitted during the above mentioned electron transition. The accuracy of the cesium clock depends on the stability of the energy levels. Reliable timing is essential for navigation. Nuclear clocks may be the clocks of the future, which are based on transitions between the energy levels of nucleons. This is because the energy levels of nucleons are more stable than that of electrons and this increases the accuracy of clocks. The difficulty in realizing nuclear clocks is that exciting nucleons requires much larger energy than exciting electrons.

a) Review Bohr's atomic model and explain the energy emission and absorption of atoms using the model.
b) What is the energy difference between those two energy levels of the cesium atom, which are used to define the second?
c) In which frequency range do cesium atoms emit photons during electron transitions between those two very close energy levels?
d) Where are nucleons found in the atoms and what types of nucleons are there?
e) What radiation does an atomic nucleus emit when nucleons make a transition to lower lying energy levels?
f) What advantage would a clock based on exciting nucleons have and what difficulties do we encounter in realizing it?

3. Collisions

When talking about the collisions of perfectly elastic objects, we must note that these objects first squeeze themselves and this is their first collision, and then they collide again a second time as they regain their initial shape. As the objects are assumed to be perfectly elastic, we also assume that the squeezing forces are equal to the expansion forces. Both collisions proceed as with inelastic objects, the only difference is that if one gains or loses, its loss or gain is also doubled.


X.
Gyönyörű
TERMÉSZET TUDOMÁNNYA
I. Kötet
NAGY VÁRADON
1808.

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

a) Review the concept of momentum and its unit.
b) Explain the concept of a closed system and the conservation of momentum applicable to a closed system.
c) Introduce the version of Newton's second law that is based on the concept of momentum.
d) Explain how Newton's third law gives rise to momentum conservation.
e) Review the phenomenon of a perfectly inelastic, central collision of two objects moving along a straight line.
f) Explain the method of calculating the final velocity (velocities).
g) Review the phenomenon of an elastic, central collision of two objects moving along a straight line.
h) Explain the method of calculating the final velocity (velocities).
i) Describe the previous collision in a reference frame defined along the line of the colliding objects' motions, moving with a velocity equal to the center-of-mass velocity of the two objects.

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 diameter of a bicycle wheel is 64 cm. A plastic light-retroreflector (so-called cat's eye) is fastened to the spokes of the wheel, at a distance of 20 cm from the axle.

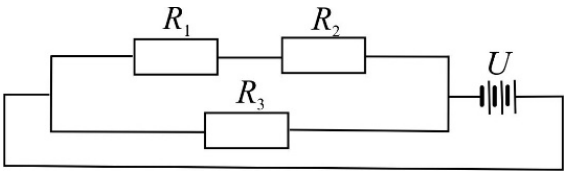
a) What is the maximum speed of the cat's eye fixed to the wheel relative to the ground, when the bike is moving with a speed of 5 km/h on horizontal ground? (The wheel of the bicycle does not slip and does not spin out.)

b) What is the magnitude of the velocity of the cat's eye relative to the ground at the moment when the line connecting the cat's eye with the wheel's axle is precisely horizontal?

a)	b)	Total
6 points	4 points	10 points

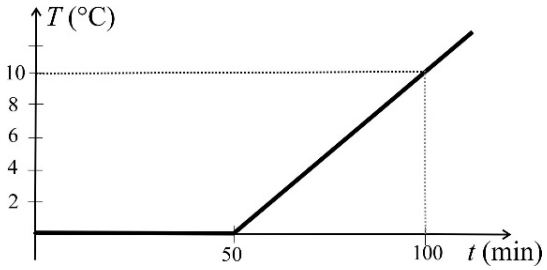
2. The circuit on the drawing is composed of three resistors and an ideal battery. Using an ideal instrument, we established that the currents through R_1 and R_3 are both equal to 0.16 A, and that the voltage on R_1 is 16 V. We measured the power on R_2 to be 5.12 W.

a) Calculate the resistances of the resistors.
b) What is the voltage of the battery?
c) What is the net resistance of the circuit?



a)	b)	c)	Total
7 points	2 points	3 points	12 points

3. We have a mixture of ice and water at temperature 0 °C in a large, closed container. The mass of the water is 10 kg, the mass of the ice is unknown. We heat the container with constant power and measure the temperature of the ice-water mixture. In the first 50 minutes, the temperature remains 0 °C, during the next 50 minutes, the temperature rises by 10 °C.



a) What is the mass of the ice that was in the container initially?
b) What was the power of the heating?

The heat capacity of the container and the losses during heating are negligible.
The heat of fusion for ice is 334 kJ/kg, the specific heat of water is 4.2 kJ/(kg·°C).

a)	b)	Total
8 points	4 points	12 points

4. The fuel tank cap of a petrol engine lawnmower is also a fuel level gauge. It consists of a series of glass rods with wedge-shaped end and different lengths (Figure 1). Assume that a single glass rod is inserted vertically into the closed fuel tank as shown in Figure 2 a). The end of the rod has the shape of a right angle wedge as shown in Figure 2 b).

a) What path will a ray of light take inside the rod, if it is incident on the top of the rod, parallel to its axis (but not precisely in the center) and the end of the rod does not reach into the petrol inside the tank?
b) What path will the same ray of light take if the end of the rod is inside the petrol?
c) Explain what we see at the end of the rod in each case.
d) Based on the above, explain the how the fuel level gauge depicted on Figure 1 works.

(The refractive index of air and petrol vapor can be taken to be 1, n_{petrol} = 1.4, n_{glass} = 1.5.)

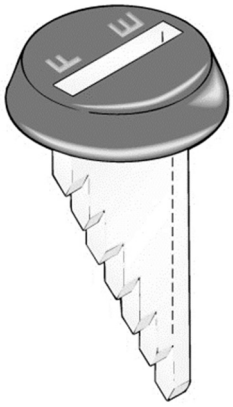


Figure 1

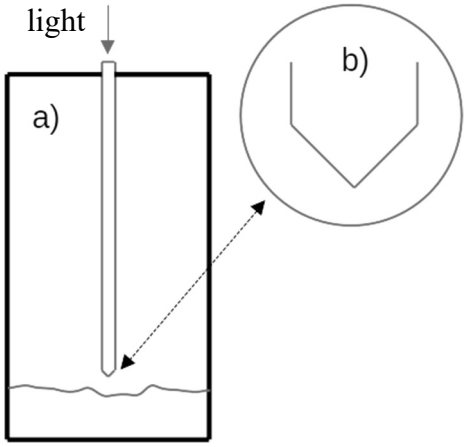


Figure 2

a)	b)	c)	d)	Total
6 points	3 points	2 points	2 points	13 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