Azonosító jel:

ÉRETTSÉGI VIZSGA • 2018. május 22.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

2018. május 22. 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, 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 this answer in the white square on the right. (You may write calculations or draw figures on this problem sheet if necessary.)

1. There is air enclosed in a balloon made from elastic material and a closed container with rigid walls. The masses of the air in them are precisely equal, their temperature is 20 °C. We want to heat the air in both to 50 °C. Which one of them requires less heat? (Heat losses and the heat absorbed by the material of the balloon and the container are negligible.)

A) The air enclosed in the balloon.
B) The air enclosed in the container.
C) An equal amount of heat is required in the two cases.
D) The question cannot be decided using the information at hand.

2 points	

2. What is the rest mass of the photon?

A) The rest masses of the photon and the electron are equal.
B) The rest mass of the photon is one 1840-th of that of the electron.
C) The rest mass of the photon is not a constant, it depends on its wavelength.
D) The rest mass of the photon is zero.

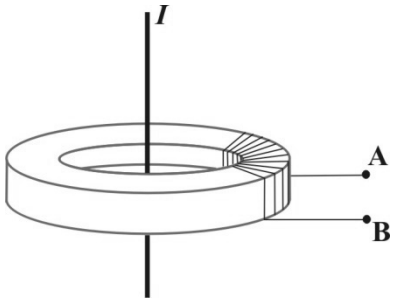
2 points	

3. Liquid concrete of density 2500 kg/m^3 is being pumped from the tube of a concrete pump with a pressure of 60 bars ($6 \cdot 10^6$ Pa). Approximately what is the height of the column of concrete, whose hydro-static pressure is equal to the pressure in the tube?

A) Approximately 2.4 meters.
B) Approximately 24 meters.
C) Approximately 240 meters.

2 points	

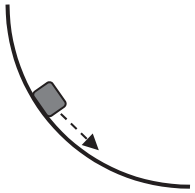
4. We wind insulated wire on an iron ring as depicted on the figure. The two ends of the wire are denoted by "A" and "B". There is a straight conductor carrying current *I* in the symmetry axis of the ring. Which of the following statements is true?



A) There can be a measurable voltage between the points "A" and "B" only if *I* is a direct current of constant magnitude.
B) There can be a measurable voltage between the points "A" and "B" only if the magnitude of the current *I* changes.
C) There can never be measurable voltage between the points "A" and "B".

2 points	

5. A point-like mass is sliding down the slope shaped like a quarter of a circle as depicted on the drawing. How do its speed and tangential acceleration change in the course of its motion? (Friction and air drag are negligible.)



A) The speed increases, the tangential acceleration increases.
B) The speed increases, the tangential acceleration decreases.
C) The speed decreases, the tangential acceleration increases.
D) The speed decreases, the tangential acceleration decreases.

2 points	

6. We create an inverted, real image of a candle on a screen using a convex lens. We then try to create another sharp image of the candle on the screen by moving the lens along the optical axis, without moving the candle or the screen. All our efforts fail. What is the magnification of the image in the original position?

A) $N < 1$
B) $N = 1$
C) $N > 1$
D) It cannot be decided using the data provided.

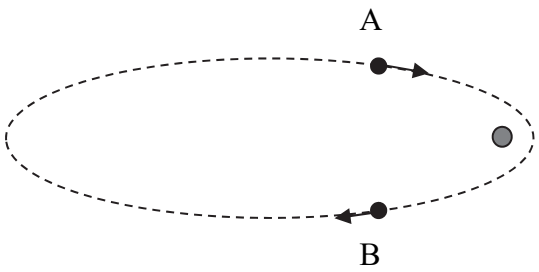
2 points	

7. The wheels of a car breaking suddenly locked up, skidded and left 20-meter-long skid marks before it stopped (the decelerating force was constant during breaking). We know that the same car under similar circumstances would break from a speed of 35 km/h to standstill on a path of 7 meters. Did the driver violate the 70 km/h speed limit this time?

A) No, he did not.
B) Yes, he did.
C) It is impossible to decide from the length of the skid marks.

2 points

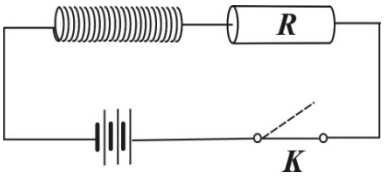
8. A comet is orbiting around the Sun on an elongated elliptical orbit. At which of the two points "A" and "B" is its speed greater? (The points are located at exactly the same distance from the Sun.)



A) At point "A", because at this point it is moving towards the Sun, so the Sun's gravitational force accelerates it.
B) At point "B", because there it still possesses most of the maximal speed attained at the perihelion.
C) The speed is equal at the two points because their distances from the Sun are equal.
D) It is not possible to decide using the data provided.

2 points

9. An ideal solenoid is inserted in a circuit as depicted on the figure. Which physical quantity will remain constant in the solenoid when the switch K is opened?



A) Only the magnitude of the magnetic induction inside the solenoid.
B) Only the magnetic energy stored in the solenoid.
C) The magnitude of the magnetic induction inside the solenoid and the magnetic energy stored in the solenoid will both be constant.
D) Neither of the above quantities will remain constant.

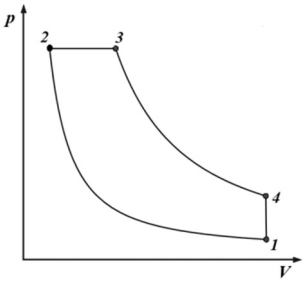
2 points

10. The frequency of the note "A" in music is 440 Hz. However, we will hear sounds of distinctly different character if we play it on a guitar, a clarinet or a piano. Why do we hear the note "A" played on different instruments to be so distinctly different?

A) Although the official frequency of the note "A" is 440 Hz, in reality each instrument emits a slightly different frequency, that is why we hear them to be different.
B) Each instrument sounds the note with a different volume (strength), that is why we perceive them to be of different character.
C) The sounds emitted by various instruments contain frequencies different from 440 Hz in different proportions, that is what makes them distinct. ☐

2 points

11. The gas in the cyclic process depicted on the adjacent *p-V* graph goes through an adiabatic compression in step 1-2 and an adiabatic expansion in step 3-4. During which step of the cyclic process does it <u>absorb heat</u>?



A) Step 1-2.
B) Step 2-3.
C) Step 3-4.
D) Step 4-1. ☐

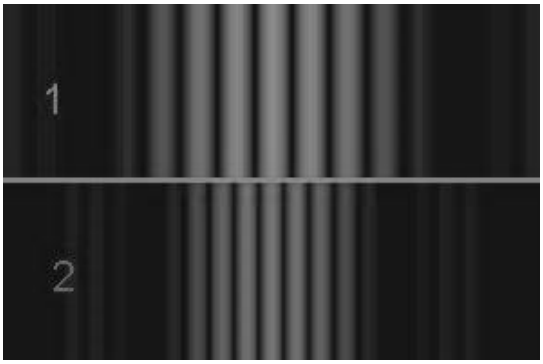
2 points

12. Two resistors are connected in series; their equivalent resistance is 10 Ω. The statements below refer to the equivalent resistance of these two resistors when connected in parallel. Which one of them is *<u>false</u>*?

A) The equivalent resistance when connected in parallel is certainly not more than 5 Ω.
B) The equivalent resistance when connected in parallel may be less than 1 Ω.
C) If the resistances of the two resistors are different, the equivalent resistance when connected in parallel lies between the two resistance values. ☐

2 points

13. We perform two interference experiments using a thin double slit. The images appearing on the screen are depicted on the figure. What could have been different in the experimental circumstances? How could the patterns have been produced?



A) They could have been produced only by using light with different wavelengths in the two experiments and an equal distance between slit and screen..
B) They could have been produced only by using different distances between slit and screen in the two experiments and light with the same wavelength.
C) They could have been produced by either of the methods described above.

2 points	

14. According to the Bohr-model of the hydrogen atom, if an excited electron jumps from a higher energy level to the energy level with principal quantum number $n = 2$, it emits visible light. What can we say about photons emitted when the electrons jump to the energy level with principal quantum number $n = 1$?

A) They are ultraviolet photons with greater energy than photons of visible light.
B) They are ultraviolet photons with less energy than photons of visible light.
C) They are infrared photons with greater energy than photons of visible light.
D) They are infrared photons with less energy than photons of visible light.

2 points	

15. We hang a small body on a vertical spring made of metal, the spring is slightly stretched as a consequence. We then heat the spring considerably ($\Delta T = 200$ °C). How does the force in the spring change as a result of the heating?

A) The force in the spring does not change as a result of the heating.
B) The force in the spring decreases as a result of the heating.
C) The force in the spring increases as a result of the heating.

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. Nuclear waste

Under the term radioactive waste, we mean waste produced by activities utilizing radioactive materials which possesses some degree of radioactivity. Radioactive waste may be categorized as low-level (with activity under 500 000 kBq/kg), medium-level (with activity between 500 000 kBq/kg – 5 000 000 kBq/kg) or high-level (activity above 5 000 000 kBq/kg). Categorizing by the lifetime, waste counts as short-lived if its half-life is less than 30 days, medium-lifetime if its half-life is between 30 days and 30 years and long-lived if it possesses a half-life longer than 30 years. The most dangerous and most difficult to manage of nuclear wastes is the high-level waste from nuclear reactors, which contains the fission products of uranium and transuranian elements produced in reactor cores. The half-life of several such isotopes exceeds 100 000 years. This waste also produces a large amount of heat, so besides appropriate radiation protection, cooling must also be provided for a while. This type of waste is first stored and cooled in spent fuel pools. Later it may be stored in deep geological repositories. These latter are caves bored into rocks deep below the surface, where earthquakes and tectonic movements are not expected to threaten the integrity of the storage facility and is not exposed to underground water.

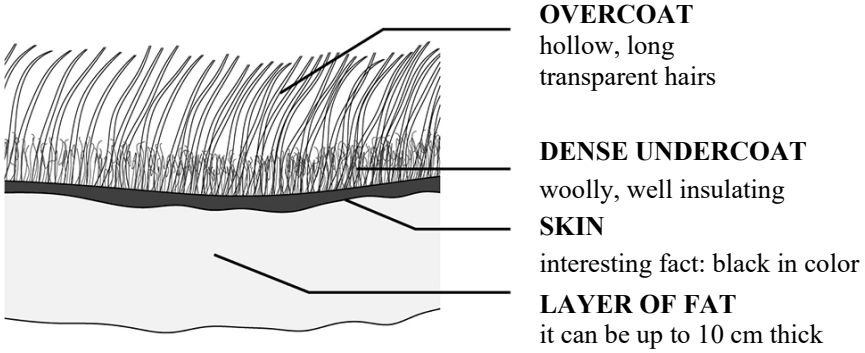
(Source: atomenergiainfo.hu. Image: publicdomainpictures.net)

List the known radioactive decay types and characterize them.
What is half-life? What do we mean by activity? What is the meaning of the unit kBq/kg?
Explain why the waste's activity is important in characterizing nuclear waste. Why is the duration of the waste's half-life important in the management of nuclear waste?
Why can wastes with the highest activity not be buried deep underground immediately after production? What is the first step in handling them?
Approximately how long does it take for nuclear waste to become low-level in activity, if it contains ^{99}Tc isotope with a half-life of 211 000 years and its initial activity is $7.8 \cdot 10^6$ kBq/kg?

2. Polar bear

Polar bears live in the harsh climate of the Arctic region where the Sun sets in October and does not rise until February. Temperatures in winter may be as low as –45 °C. When scientists tried to track polar bears from the air, they could not use traditional cameras because the animals blend perfectly into the snowy landscape. They tried tracking with infrared cameras but failed because due to their insulating fur, the polar bear does not appear to be warmer than its surroundings.

The structure of the polar bear's fur is complicated. It is extremely dense and is composed of hairs of two different types; short, woolly ones and long, tube-like hairs which contain air. This special fur behaves as a heat-trap, the precise way it functions is still being investigated. There is a thick layer of fat surrounding the bear under its skin. The hairs of the fur are covered with tallow, so the fur does not wet under water, but retains air. Even its soles are hairy and well insulated. Small leather cushions on the sole prevent slippage on ice. The several hundred-kilogram animal can change its direction abruptly while on the hunt. Despite its great body, the polar bear is not clumsy, it can swim with a speed of 10 km/h and run at about 40 km/h.



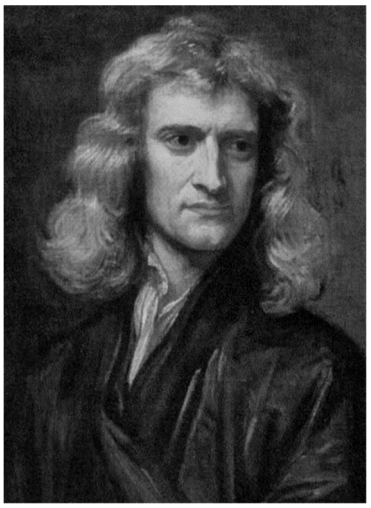
Images: http://www.termeszettar.hu/anyagok/jeges/jeges.htm

Describe and characterize the three methods by which heat can be transferred.
The muscle temperature of predators is about 37 °C, that is what makes fast movement possible. What is the external temperature of the polar bear's fur? What consequence does this have on the tracking of the polar bear?
The bear's fur does not wet even when under water, it retains air. How does this help keeping the body temperature in water? What other advantage could retaining air have in the context of moving in water?
What surface properties can help the hairs to retain air?
How can the cushions of the sole help surefooted movement and fast changes in direction?
What can the average speed of a bear be if, during its movement it covers half the distance swimming and half the distance running?

3. The laws of Newton

If only one force acts on a body or a point of a body, with one magnitude and direction, this entails simple motion. The only thing to note is that after this force acted and then ceased acting on the body, it is said to be a dead force and the body, due to its inertia will move in a straight line in the direction and with the speed obtained, provided that no obstacles are encountered.

Schirkhuber Móricz: The basics of theoretical and experimental natural philosophy.
Pest, 1851



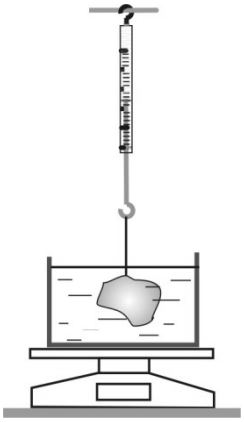
Review the first law of Newton. Demonstrate its validity using an everyday example. What is an inertial reference frame? What is the connection between inertial frames and Newton's laws? What does the second law of Newton state about the acceleration of bodies? Demonstrate using an everyday example. What is momentum? Explain the law using the concept of momentum as well.
Explain the third law of Newton. Demonstrate its validity using an everyday example. Review the law of momentum conservation. Using Newton's laws, explain momentum conservation for the case of two interacting bodies.
Explain the principle of independence of forces, which is sometimes called the fourth law of Newton.

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 fill water up to a height of 20 cm in a container whose weight is 0.5 kg and whose area of cross-section is A = 150 cm^2. We place this on a weighing scale and lower a 7.9 kg piece of iron into the water, such that it is immersed fully in the water, but does not touch the bottom of the container, being suspended on a spring scale.



What are the values we can read from the weighing scale and the spring scale at this point?

($g = 9.8\ \frac{\text{m}}{\text{s}^2}$, $\rho_{water} = 1\ \frac{\text{kg}}{\text{l}}$, $\rho_{iron} = 7.9\ \frac{\text{kg}}{\text{l}}$)

Total
12 points

2. We would like to connect two resistor wires having a nominal power of 40 Watts each, in series. One resistor wire was designed for a 110 V voltage, the other for a 230 V voltage. If any of the wires is operated at a voltage more than 10 % higher than its nominal voltage, it will be burned out. What is the maximum voltage that we can switch on the two wires connected in series without the risk of one of them burning out?

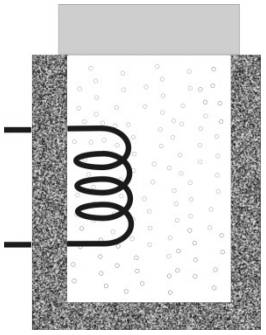
Total
12 points

3. A spacecraft begins orbiting around an unknown planet on a circular orbit with a radius of 120 000 km. The period of the orbit is 8 days. What is the mass of the unknown planet? (The radius of the orbit given is measured from the center of the planet.)

($\gamma = 6.67 \cdot 10^{-11} \ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{kg}^2}$)

Total
10 points

4. There is an opening of 100 cm^2 area on the top of the 10-liter container on the adjacent figure. We place a lid of 10 kg mass onto the opening, with which we enclose the air in the container in an airtight manner. We then begin to operate the 6 W heating element built into the container and observe that the air inside lifts the lid after 3 minutes. The external pressure is 10^5 Pa, the external temperature 20 °C, the lid and the container do not insulate well, so there is heat loss during the process.



a) What is the temperature of the air inside at the moment that the lid is lifted?
b) What is the amount of heat necessary to warm the air?
c) What percentage of the heat given off by the heating element was used to warm the air?

The density of air is $\rho = 1.29\ \frac{\text{kg}}{\text{m}^3}$, the specific heat of air at constant volume is $c_v = 712\ \frac{\text{J}}{\text{kg} \cdot \text{K}}$, $g = 9.8\ \frac{\text{m}}{\text{s}^2}$

a)	b)	c)	Total
6 points	3 points	4 points	13 points

To be filled out by the examiner evaluating the paper!

	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