Azonosító jel:

ÉRETTSÉGI VIZSGA • 2020. május 19.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

2020. május 19. 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. Two identical bricks are placed on a horizontal, plane table top, one on top of the other – the bricks are not fastened to each other. We tie a string to the upper brick and start to pull it with a horizontal force. Can it be possible to drag (move) both bricks by pulling on the upper brick? (Friction is not negligible, neither between the bricks, nor between the lower brick and the table.)

A) Yes, if we pull on the upper brick carefully enough, the lower brick will move together with it in every case.
B) No, the friction force between the lower brick and the table is always greater, than the one between the two bricks, so the lower brick always remains at rest.
C) It is possible for the lower brick to start moving as well, if the coefficient of friction between the bricks is greater than the one between the lower brick and the table.

2 points	

2. We connect a 100 Ω resistor cable to 10 V constant voltage. How much charge will flow through a cross-section of the cable during a 30 second interval?

A) 30 000 Coulombs.
B) 300 Coulombs.
C) 3 Coulombs.
D) 0.03 Coulombs.

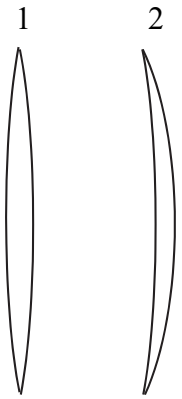
2 points	

3. The symbol for a given isotope is, $^{3}_{2}X$ where X stands for the chemical symbol of an element in the periodic table. Which element could X be?

A) "H" as this is the hydrogen isotope with mass number 3 (tritium).
B) "He" as helium is the second element and this is an isotope of helium.
C) "Li" as lithium is the third element in the periodic table and this is an isotope of lithium.

2 points	

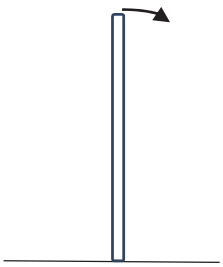
4. In air, a glass lens creates an inverted, real image of an object on a screen with magnification less than one. The adjacent figures depict the cross sections of two lenses. What could the shape of the lens in the problem be like?



A) It could only be like the lens in figure 1.
B) It could only be like the lens in figure 2.
C) Both depicted lens shapes are possible.
D) None of the depicted lens shapes is possible.

2 points	

5. A rod standing vertically in equilibrium is tipped over and falls on the table. There is no friction between the rod and the table. The upper end of the rod moves right. Does the bottom end of the rod move and if yes, in which direction?



A) It moves right as well.
B) It does not move.
C) It moves left.

2 points	

6. We shine white light on a prism and it is decomposed into colors. We then place a second prism in the path of the 630 nm wavelength red, monochromatic component. Which statement is true?

I. The red light passes through the second prism without changing direction.
II. The red light does not break up further into components.

A) Only statement I. is true.
B) Only statement II. is true.
C) Both statements are true.
D) Neither one of the statements is true.

2 points	

7. Two spectral lines of the spectrum of hydrogen are observed in an experiment: a red one and blue one. One line is emitted when the electron of the hydrogen atom jumps from the shell with principal quantum number 3, to that with principal quantum number 2. The other when the electron jumps from the shell with principal quantum number 5 to that with principal quantum number 2. Which line corresponds to which transition?

A) The blue one to the 5 → 2 transition, the red one to the 3 → 2 transition.
B) The blue one to the 3 → 2 transition, the red one to the 5 → 2 transition.
C) Both cases are possible depending on the previous excited states of the atoms.

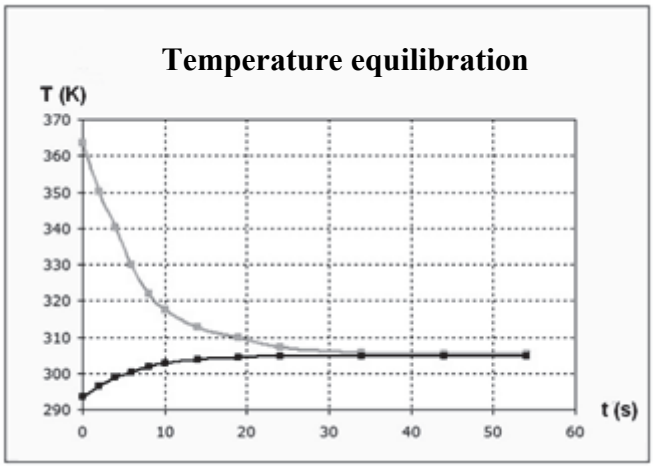
2 points	

8. We first apply a U_{DC} = 230 V magnitude constant voltage on a coil, then a U_{eff} = 230V effective value alternating voltage. What can we say about the relationship between the currents I_{DC} and I_{eff} that flow in the coil as a result?

A) $I_{DC} > I_{eff}$
B) $I_{DC} = I_{eff}$
C) $I_{DC} < I_{eff}$

2 points	

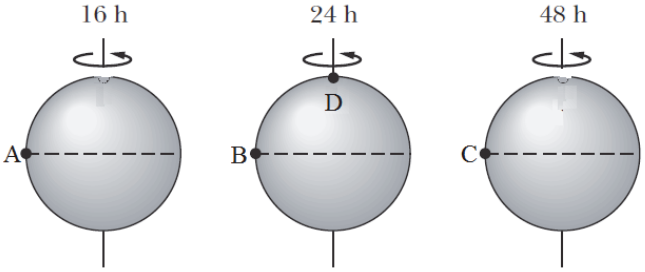
9. We place a hot (364 K temperature) solid material into a liquid of temperature 21 °C. The adjacent graph shows the temperature of the two materials as a function of time. Based on this graph, which of the two materials has the greater specific heat capacity?



A) The solid material.
B) The liquid material.
C) The specific heat capacities of the materials are equal.
D) The question cannot be decided using this graph.

2 points	

10. Let us assume that astronomers discover three exoplanets of the same size and mass orbiting around a star. The planets are perfectly spherical in shape and differ from each other only in the revolution period around their axis. Imagine that we send expeditions to measure the gravitational acceleration at the locations marked with letters on the planets. At which point would the gravitational acceleration be the greatest and at which point the smallest?



A) It would be the greatest at point A and the smallest at point C.
B) It would be the greatest at point C and the smallest at point A.
C) It would be the greatest at point B and the smallest at point D.
D) It would be the greatest at point D and the smallest at point A.

2 points	

11. We throw a heavy ball in a horizontal direction. In which case will it fly farther: if it is thrown from a height of 50 meters with a velocity of 10 m/s, or from a height of 100 meters with a velocity of 5 m/s? Air drag is negligible!

A) If we throw it from a height of 50 meters with 10 m/s initial velocity.
B) If we throw it from a height of 100 meters with 5 m/s initial velocity.
C) It flies the same distance in these two cases.

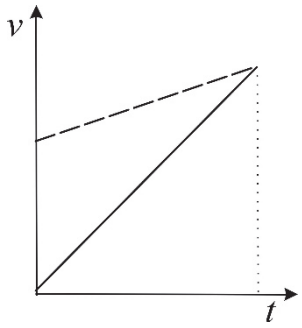
2 points	

12. An artificial satellite is orbiting around Earth on an elongated elliptical orbit. Does the gravitational force exerted by Earth do work on the satellite during its motion?

A) No, it does not because the gravitational force is always perpendicular to the displacement of the satellite.
B) Yes it does, that is why the satellite moves faster on the sections closer to Earth of its trajectory.
C) The question cannot be decided using the information given.

2 points	

13. The adjacent *v(t)* graph shows the velocity of two bodies that start from the same point in space and move along a straight line. At which point in time does one body overtake the other?



A) At the time point where the two lines intersect.
B) Neither of the bodies overtakes the other.
C) The question cannot be decided without information on the acceleration.

2 points	

14. We measure the density of a glass of water at two different temperatures (all other environmental parameters are the same). The two density values are equal. What can the difference between the two temperature values be? Select the correct statement from the possibilities below.

A) The temperature difference may be 20 °C, but it cannot be 2 °C.
B) The temperature difference may be 2 °C, but it cannot be 20 °C.
C) Both values are possible.
D) Neither of these values is possible.

2 points	

15. Two positive *Q* charges of equal magnitude are fixed to a plane insulator. We place a point-like, free *q* charge at the midpoint of the section connecting the charges, which is at equilibrium here. If we move the *q* charge out of its equilibrium in a direction along the line of the fixed *Q* charges, it will not return to its point of equilibrium. If we move it out of its point of equilibrium in the direction perpendicular to this, it will return. What is the sign of the free *q* charge?

A) Negative.
B) Positive.
C) It may be both positive or negative.
D) No such equilibrium point is imaginable.

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. The Earth Similarity Index - ESI

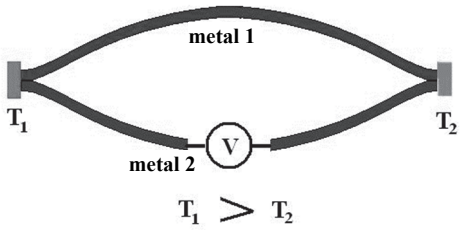
The so-called Earth Similarity Index (ESI) is a number that researchers use to express the similarity of celestial bodies discovered inside and outside of the Solar System to planet Earth. Its value for Earth is precisely one, and for other planets and celestial objects it is a number between 1 and 0, the value of which is smaller for planets that are more different from Earth. To calculate it, the factors taken into account are the radius of the planet, its average density, the escape velocity on its surface (second cosmic velocity) and its surface temperature. However, in comparing planets outside the Solar System to Earth, instead of the surface temperature the so-called "planetary equilibrium temperature" is used. This latter is calculated from the radiation arriving from the vicinity of the planet that is mostly reflected from the planet. The reason is that for an exoplanet we cannot determine some factors that influence the surface temperature such as the density and composition of the atmosphere, or processes generating heat inside the planet. The planetary equilibrium temperature can thus differ a great deal from the global mean temperature actually measurable on the surface. For example for planet Earth the planetary equilibrium temperature is 255 K, while the measured global mean temperature is 288 K. The table below contains the data for a few celestial bodies of the Solar System and their value of the similarity index. (The table contains the actual surface temperature.)

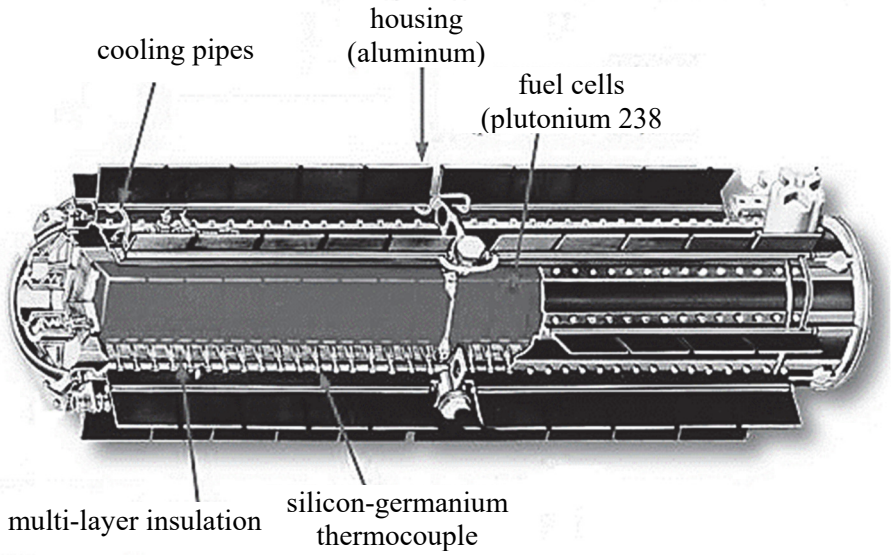
object	escape velocity (km/s)	surface temperature (K)	ESI
Earth	11.2	288	1.0
Mars	5.04	227	0.7
Mercury	4.26	440	0.6
Jupiter	60.3	152	0.29
Pluto	1.23	40	0.075
Moon	2.35	220	0.56

a) What is the escape velocity (second cosmic velocity)?
b) What does the gravitational acceleration on the surface of a planet depend on provided we neglect the effect of the planet's rotation around the axis?
c) How is energy transported from the central star to the surface of a planet?
d) Name two properties that the *planetary equilibrium temperature* does not take into account, even though it influences the actual surface temperature of the planet. Why does the index neglect these?
e) Is Earth's mean surface temperature higher or lower than its *planetary equilibrium temperature*? What can the reason for the difference be?
f) Which of the celestial bodies in the table is the most similar to Earth? How do the data in the table support this classification?
g) Why is the ESI index of Pluto much smaller than that of the Moon?

2. The radioisotope thermoelectric generator (RTG)

For spacecraft exploring the remote planets of the Solar System, solar panels are not efficient enough for providing power - the radioisotope thermoelectric generator (RTG) is the appropriate solution. If a circuit is built from two metals (or semiconductors) and a temperature difference is generated between the two contact points where these metals are joined, a voltage difference arises in the circuit, the magnitude of which depends on the temperature difference. Thermocouples described above are used in the RTG to generate electric voltage. One contact point of the two metals is cooled by space, the other is heated by radioactive decay. For fuel we need an isotope with the highest possible energy emission per unit mass, which decays with high energy, low penetration radiation (for easy shielding). The half-life cannot be very short because the energy supply must last for the long journey, but it cannot be too long either because then the heating power is low. The most suitable material turned out to be the artificially created plutonium 238 isotope. It has a high density, and is an alpha-emitter with a half-life of 88 years. The radioactive heating element is placed along the axis of the cylindrical generator as shown in the figure. Thermocouples are positioned in a radial direction, perpendicular to it, with one of their junctions being heated by the heating element, while the other being connected to cooling pipes. Generators like this are being used for example in the Pioneer, Voyager, Galileo, Ulysses and Cassini spacecraft. (Pictures: Wikipedia)



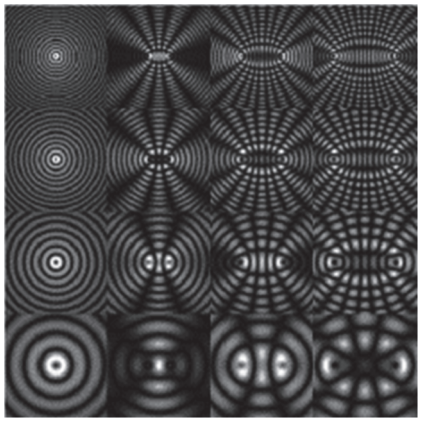


a) Review the types of radioactive decay.
b) Why is heat generated during radioactive decay?
c) Why is the heating power given off by the shorter half-life isotope greater than that with the longer half-life isotope?
d) Why was an α-emitter isotope chosen for RTG?
e) What is the decay product element of the α-decay of plutonium-238?
f) The multi-layer insulation is placed between the two ends of the thermocouple. Why?
g) The Voyager-1 spacecraft was launched in 1977 and it will have sufficient power to send radio signals to Earth until 2025. By what factor does the radiation power of the fuel cells in the RTG reduce during this time?

3. Waves

All elastic bodies and others too are created so that forcing a small particle in motion will make a whole series of others move one after another. If the movement of the first particle regularly returns to its first state, the motion of the others will also be such, however all following particles will start their motion a moment later than the particle before them.

Fuchs Albert: Elements of natural science. 1845, Kassa



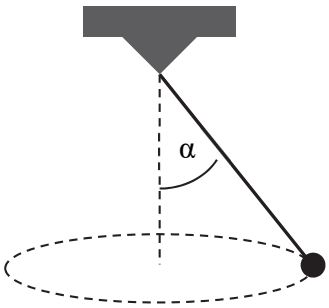
a) What do we mean by transversal and longitudinal waves? What are the physical quantities that describe the most important properties of waves and how are they related?
b) List three distinctive wave phenomena and give an example for each one that can be observed in everyday life.
c) Review the two-slit interference of light and explain the directions of constructive and destructive interference.
d) Review the phenomenon of light polarization. Why is this suitable for differentiating between longitudinal and transversal waves?
e) Review the experiment that supports the wave nature of electron.
f) Why does this experiment contradict the particle model of electrons?

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 object shown in the figure is tied to a string and moves along a circle with constant speed, while the string traces the lateral surface of a cone (conical pendulum). The length of the string is 1 m, the angle it encloses with the vertical is α = 60°.



What is the frequency of the object's motion?

$g = 9.8\ \text{m/s}^2$.

Total
11 points

2. The volume of a hot air balloon is 2800 m^3, the air inside it can be heated with the gas burner in the basket to a temperature of 100 degrees Celsius. The overall mass of the balloon, the basket, the burner, the fuel tanks and the sacks of sand used as ballast is 400 kg.

a) At most how many people of 75 kg mass can climb into the basket so that the balloon is still able to take off from the ground if the external air temperature is 20 °C?
b) How many 10 kg sacks of sand must be thrown out if the fuel is exhausted, the temperature of the air inside the balloon decreases to 90 °C, but we do not want the balloon to sink? (The number of people in the basket is the number obtained in the previous problem.)

The external pressure is 10^5 Pa, the density of air at this pressure and at 20 °C is $\rho_0 = 1.2041$ kg/m^3. The balloon is open at the bottom, so the pressure inside the balloon is the same as the external pressure. We assume that the balloon does not attain a height at which the decrease in pressure and air temperature would be considerable.

a)	b)	Total
8 points	5 points	13 points

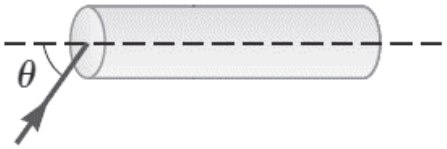
3. In conventional nuclear reactors, we obtain energy by fission of the uranium-235 isotope. During one typical fission process (but this is not the only possible process) the uranium nucleus reacting with a neutron will split into a cesium isotope with mass number 137 and a rubidium isotope with mass number 96. The energy released in this process is 137 MeV.

a) Write down the reaction equation for this fission process.
b) How many grams of uranium will release 1 kJ of energy during this fission?
c) The cesium created in the process is radioactive; its half life is about 30 years. Calculate the number of years required for the activity of the cesium to decrease to 1% its initial value.

The mass of the ^{235}U nucleus is $M_U = 235.04\ u$, where $u = 1.6605 \cdot 10^{-27}$ kg is the unified atomic mass unit.

a)	b)	c)	Total
5 points	4 points	5 points	14 points

4. The index of refraction of a glass rod is 1.36 . What is the largest angle θ at which a ray of light can enter the rod at the center of its end surface, such that upon reaching the side wall of the rod it undergoes total internal reflection?



Total
9 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