ÉRETTSÉGI VIZSGA • 2019. május 20.

FIZIKA ANGOL NYELVEN

EMELT SZINTŰ ÍRÁSBELI VIZSGA

2019. május 20. 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 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. **We throw a body that has 1 kg mass in a horizontal direction with an initial speed of 5 m/s, at a height of 2 m above the ground on the Earth and also on the Moon. In which case will it travel a greater distance?**

    A) On the Earth, because here the atmosphere will slow its vertical descent.
    B) On the Moon, because gravitation there is smaller.
    C) They travel equal distances, but motion on the Moon will last longer.

    2 points

2. **Which particle has a greater de-Broglie wavelength: the proton or the electron?**

    A) The electron, because it is much lighter so it also moves faster than the proton.
    B) The proton, because the wavelength is proportional to the mass.
    C) The wavelengths of the two particles are equal, as their charges are also equal.
    D) It is not possible to decide, the wavelength of the proton or the wavelength of the electron may also be greater, depending on the circumstances.

    2 points

3. **Which force binds the galaxies together?**

    A) The gravitational attraction of the stars and other material composing the galaxy, i.e. the force of gravity.
    B) The electric charge of the stars, i.e. the Coulomb force.
    C) The nuclear forces that arise due to nuclear fusion processes within the stars.
    D) The galaxies are not held together by any force, stars are continuously moving away from the center, but in the majority of cases the time past since the formation of the galaxy is not enough for the stars to have scattered completely.

    2 points

4. **All the light bulbs are shining to start with in the circuit depicted on the drawing. We then connect a wire of negligible resistance between points A and B. What happens next?**
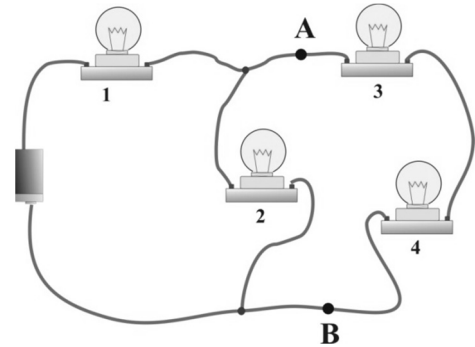
   A)   Only light bulb 1. will continue shining.
   B)   Only light bulbs 1. and 2. will continue shining.
   C)   Only light bulbs 1., 3. and 4. will shine.
   D)   All the light bulbs will continue shining.

   2 points

5. **On the adjacent *p-V* diagram each arrow stands for a thermodynamic process of a gas of constant quantity, enclosed in a container. The initial and final temperatures of the gas are equal in one of these processes. Which is this process?**
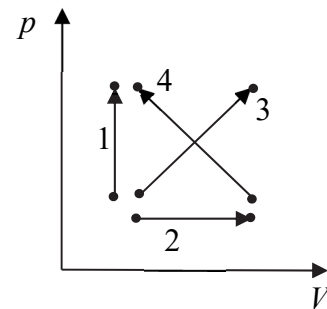
   A)   Process 1.
   B)   Process 2.
   C)   Process 3.
   D)   Process 4.

   2 points

6. **A crate is placed onto the platform of a truck that is standing still, without fixing it to anything. The truck starts accelerating, but the crate does not slip on the platform. Which of the following statements is true?**

   A)   The crate is being accelerated by the force of friction and work is done on the crate by the friction force.
   B)   The crate is being accelerated by the force of friction, but no work is done by friction because the surface of the platform and the crate do not move with respect to each other.
   C)   The crate is not being accelerated by the force of friction because friction can only slow things.

   2 points

7. **The nuclei of a radioactive isotope transform to stable nuclei through two consecutive decay processes. They first emit an α-particle then a β-particle. What is the half-life of the β decay process if the half-life of the α-decay process is one year?**

   A) About 8000 years, because the α-particle is about 8000 times heavier than the β-particle.
   B) The half-lives of the two decay processes are equal.
   C) It is impossible to tell because there is no direct relationship between the two half-lives.

   2 points

8. **In the adjacent setup an object is placed at a distance _r_ from a convex mirror of radius _r_. Where is the image formed? (_G_ is the geometrical center, _O_ is the optical center of the mirror.)**
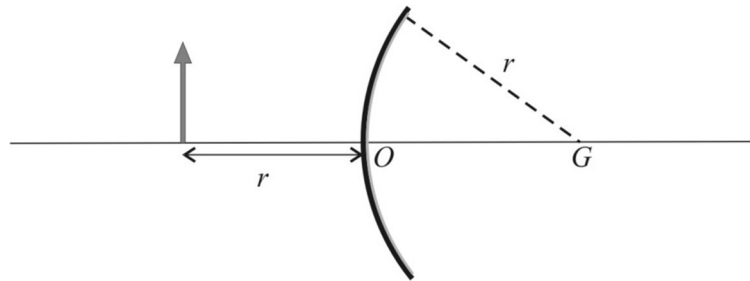
   A) The image is formed at infinity.
   B) The image is formed behind the mirror, i.e. on the right hand side, at a distance _r_/3 from the point _O_.
   C) The image is formed in front of the mirror, i.e. on the left hand side, at a distance _r_/3 from the point _O_.
   D) The image is formed just at the location of the object, but it will be inverted.

   2 points

9. **Two cylinders of equal masses, made of a homogeneous material are rolling with equal velocities without any slipping. One cylinder is shorter, but its radius is two times larger than that of the other. Which cylinder has a greater rotational energy?**

   A) The cylinder with the larger radius has a greater rotational energy.
   B) The cylinder with the smaller radius has a greater rotational energy.
   C) The rotational energies of the two cylinders are equal.
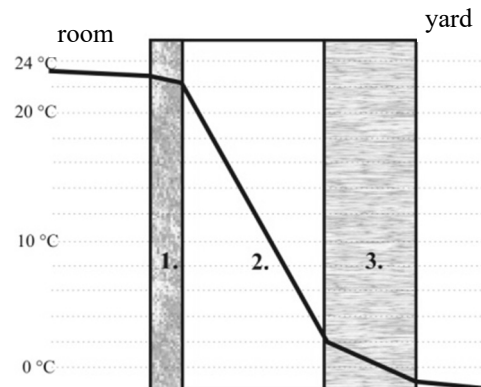
   2 points

10. **We would like to determine the point on the line connecting the centers of Earth and Moon where the gravitational effects of the two celestial bodies cancel each other precisely. How should we proceed?**

   A)   We must divide the distance between the centers of the two bodies inversely proportional to their masses.
   B)   We must divide the distance between the centers of the two bodies directly proportional to their masses.
   C)   We must divide the distance between the centers of the two bodies proportional to the squares of their masses.
   D)   We must divide the distance between the centers of the two bodies proportional to the square roots of their masses.

2 points	

11. **The adjacent figure shows how the temperature changes inside a house wall consisting of various layers as we progress from the inside towards the outside. Which layer is the best insulator?**

   A)   Layer 1.
   B)   Layer 2.
   C)   Layer 3.

2 points	

12. **Approximately how long does it take for an electron to reach our home electric socket from the power plant through the high-voltage power lines of the electric company?**

   A)   Approximately 1/50-th of a second, as the frequency of alternating current is 50 Hz.
   B)   A fraction of a second as the speed of current is the same as the speed of light.
   C)   The electron can never reach us, because a continuous connection is broken by transformers.

2 points	

13. **We place a rigid paper with two narrow, parallel slits in front of a screen. When we illuminate the paper with monochromatic light, we observe interference fringes on the screen. We then cut a third slit in the paper, exactly like the other two such that the distances between adjacent slits are equal. Can we observe interference fringes if we illuminate the paper again?**

    A)   Yes, interference effects will again be created.
    B)   No, interference effects can only be created using two slits.
   **C)**   No, interference effects can only be created by using an even number of slits.

2 points

14. **Three point charges are at rest and are all in equilibrium in the electric fields of each other. Can the charges be all of equal magnitudes?**

    A)   Yes, if there are positive and negative charges among them as well.
    B)   Yes, but only if the charges are placed along a straight line.
    C)   No, this is not possible if the magnitudes of all of the charges are the same.
    D)   No, free charges can never be in equilibrium in each others electric fields, not even if their magnitudes are different.

2 points

15. **We build the "barbell" on the adjacent figure from two weightless rods of identical lengths fixed at right angles to each other and two point-like masses of equal weight. We would then like to balance this on the tip of a vertical, pointed stick. How can we do this?**
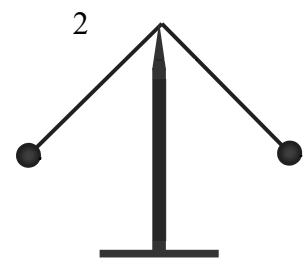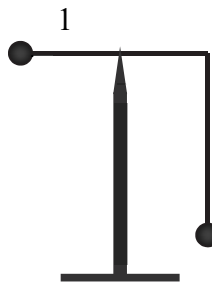
    A)   Only as depicted on figure 1, supported at the center of one of the rods.
    B)   Only as depicted on figure 2, supported at the point where the two rods are joined together.
    C)   We can balance it according to both depicted ways.
   **D)**   None of the depicted methods will work.

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.

Comparing rotation and translation

„As a rigid body is forced to rotate around an axis, such as a millstone or a wheel, each massive part acquires a force because of which it tries to move away from the axis. As the speed increases, this may prevail over the forces holding the parts together and the pieces will then fly apart.”

Thüringer Ambró: Theoretical and experimental natural science
Pest, 1853
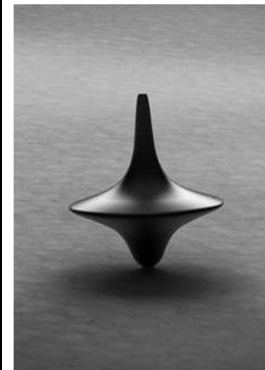
Compare the kinematic and dynamical quantities characterizing the motion of a point-like body along a straight line (distance, velocity, acceleration, mass, force) with those describing the rotation of an extended, rigid body around a fixed axis. Explain the correspondence between the two sets of quantities. Review the dynamical equation for translation and for rotation around an axis. What is the condition for uniform movement in the two cases? Define the energy associated with the motion in the two cases. Explain how the total energy of motion of a solid, homogeneous cylinder that is rolling without slipping can be calculated and discuss the relationship between its translation and rotation. Review the concepts of momentum and angular momentum and demonstrate the laws of their conservation using a practical example for each one.

The position of electrons in the atom

„Pauli was an excellent theoretical physicist. His name will always be inseparable for his friends from the mysterious effect named Pauli-effect. It is well known, that theoretical physicists are all very clumsy with experimental devices and that they break expensive, complicated instruments as soon as they touch them. Pauli was such an excellent physicist that the instruments broke as soon as he stepped into the laboratory.”

George Gamow: The history of physics, Budapest, 1961
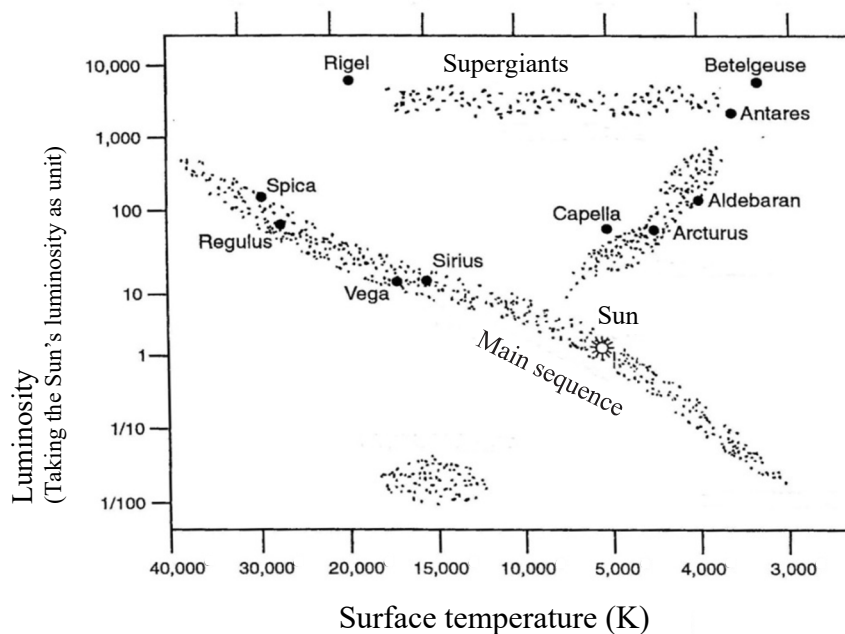
Wolfgang Pauli (1900-1958)

According to the atomic model of quantum mechanics, what quantum numbers characterize the state of an electron inside the atom? Formulate the Pauli principle. What values can the various quantum numbers acquire? What does Hund's rule state? In what order are the electron shells filled in the periodic table of the elements? What is the relationship between the quantum numbers of an atom's "outermost" electron and the place the atom occupies in the periodic table? What do the periods, groups and blocks of the periodic table express?

Read the text below carefully and answer the following questions using the information it contains!

The life of the Sun and the stars

The so-called Hertzsprung-Russel diagram shown below is used in astronomy. The temperature of a star's surface is plotted on the horizontal axis, and its luminosity, i.e. the amount of energy it emits per unit time is plotted on the vertical axis. This latter is usually compared to the energy emitted by the Sun, so the luminosity of the Sun is unity. Each star can be placed on the diagram given these two quantities, each dot plotted on the figure corresponds to a star. The position of the Sun and a few well-known stars are marked on the plot. It can be seen that the stars form well separated, distinct groups. The line-like set stretching from the upper left corner to the lower right one is called the main sequence of stars. The location of a star on this diagram is not constant, it may belong to different groups during different phases of its life. For example, our Sun will deplete its primary source of energy in a few billion years and transform – it will expand to become a red giant and will emit much more energy than it does now. In the last phase of its long life it will probably belong to the white dwarfs.

Source of original picture: http://elte.prompt.hu/sites/default/files/tananyagok/InfraredAstronomy/ch09s02.html

a) What type of energy producing processes take place in the interior of stars?

b) What elements is the Sun composed of? What is the "fuel" for the Sun's energy production and what is the end product of the process?

c) What is the surface temperature of the Sun now?

d) To which large group of stars does the Sun belong today? Name another well known star that belong to the same group. Is the luminosity of this star smaller or greater than that of the Sun?

e) Which set on the diagram depicts red giants? Name a red giant depicted on the diagram.

f) Which set on the diagram depicts white dwarfs? Will the luminosity and the surface temperature of the Sun be smaller or greater in this last phase of its life than it is today?

| 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 thin homogeneous rod of 0.5 kg mass depicted on the figure is hanging from a vertical string tied to one of its ends and is in equilibrium, being immersed in water to exactly half of its length.**

   What is the force arising in the rope? What is the density of the rod?

   $$g = 9.8 \ \frac{m}{s^2}, \ \rho_{water} = 1\frac{g}{cm^3}$$
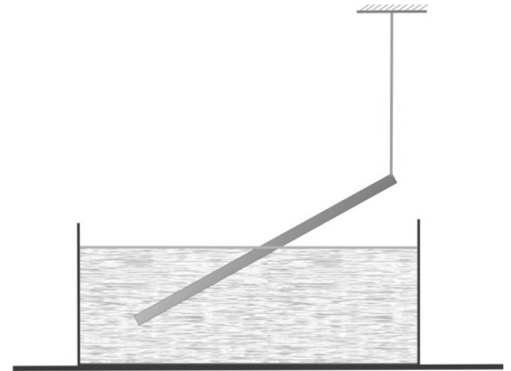
Total
12 points

2. **There are three different isotopes marked with the letters A, B and C in the waste from a nuclear power plant with half-lives $T_A = 1000$ years, $T_B = 2000$ years and $T_C = 10000$ years. The activity of each isotope in the sample is $A_A = 6 \cdot 10^7$ Bq, $A_B = 2 \cdot 10^6$ Bq, $A_C = 1.2 \cdot 10^5$ Bq. The waste must be kept in a safe storage until the activities of each of the three isotopes decrease below 4 Bq separately.**

a) What will the activities of each of the isotopes in the sample be after 10000 years?
*b)* Approximately how long must the waste remain in safe storage? Because of which isotope?

a)	b)	Total
5 points	7 points	12 points

3. **A proton enters Earth's magnetic field from space with a velocity of $4{\cdot}10^6$ m/s. The magnitude of the magnetic field is 10^{-6} T and can be regarded homogeneous in this region. The angle enclosed between the vectors of the magnetic field induction and the proton's velocity is 60°. The proton moves with a constant velocity along a straight line parallel to the direction of the magnetic induction and is forced to perform uniform circular motion by the field in the plane perpendicular to that. It thus moves on a spiral trajectory in Earth's magnetic field.**

a) How many revolutions does the proton cover on its spiral trajectory in one second?
b) How does the magnitude of its velocity change during this time?
c) What is the distance covered by the proton during a 0.1 s interval?

(The mass of the proton is $1.67{\cdot}10^{-27}$ kg, its charge is $1.6{\cdot}10^{-19}$ C. The drag of Earth's atmosphere is negligible at a great distance from Earth's surface. The force of gravity is negligible.)
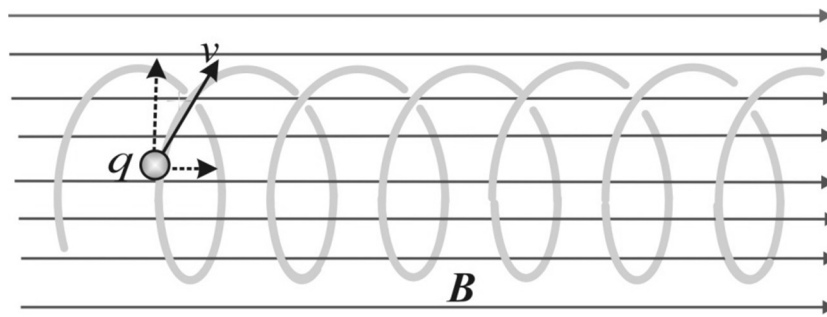
a)	b)	c)	Total
8 points	2 points	2 points	12 points

4. **We generate an $f = 1.18 \cdot 10^{10}$ Hz frequency electromagnetic oscillation in a resonant circuit that consists of an ideal capacitor with $C = 10$ pF capacitance and a coil.**

   a) What is the inductance of the coil in the resonant circuit?
   b) What is the energy in the circuit if the maximum voltage of the capacitor is 2V?
   c) What is the maximum current in the coil?

a)	b)	c)	Total
4 points	3 points	4 points	11 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

	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