ÉRETTSÉGI VIZSGA • 2023. május 23.

FIZIKA
ANGOL NYELVEN

EMELT SZINTŰ
ÍRÁSBELI VIZSGA

minden vizsgázó számára

2023. május 23. 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.

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. **A wheel with radius *r* is rotating with angular speed *ω* and because it is rolling on the ground without slipping, it is moving forward with speed *v*. What will the speed of the translation motion of a wheel with radius 2*r* be, if it rotates with angular speed 2*ω* and rolls on the ground without slipping?**

   A) 0,5 *v*.
   B) *v*.
   C) 2 *v*.
   D) 4 *v*.

2 points	

2. **We measure the focal length of a concave spherical mirror using visible light to be 40 cm. What would the measured focal length be if we repeated the measurement with infrared light?**

   A) Greater than 40 cm.
   B) 40 cm.
   C) Less than 40 cm.

2 points	

3. **The dwarf planet Pluto and its satellite Charon which has a large mass (but smaller than Pluto) orbit around their joint center of mass. Which one of them has a greater acceleration?**

   A) Pluto, because it has a larger mass.
   B) Charon, because they attract each other with equal forces but Charon has a smaller mass.
   C) Their accelerations are equal because their angular speeds are also equal.
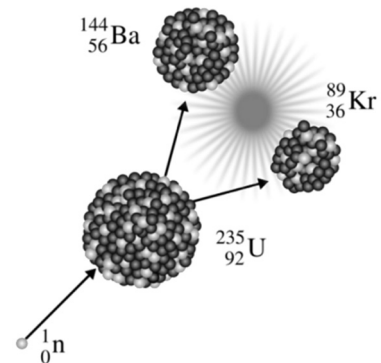
2 points	

4. The velocity-time and acceleration-time graphs of three bodies were plotted in an experiment, but the graphs were later mixed up. Determine which graphs correspond to each other.
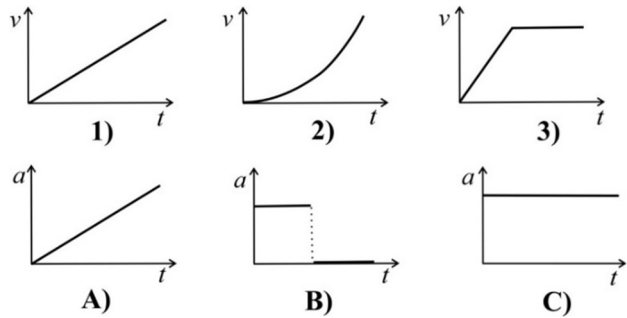
A) 1-A; 2-C; 3-B.
B) 1-C; 2-B; 3-A.
C) 1-C; 2-A; 3-B.

2 points	

5. How many free protons and neutrons are created in the fission process depicted in the figure?

A) 1 proton and 2 neutrons.
B) 0 protons and 3 neutrons.
C) 2 protons and 1 neutron.
**D)** 3 protons and 0 neutrons.

2 points	

6. Following maintenance, a heat engine can absorb twice as much heat from the boiler per unit time as before the maintenance. The heat given off on the cooler fins per unit time is also doubled after maintenance. How did the efficiency of the heat engine change?

A) The efficiency was doubled.
B) The efficiency remained the same.
C) The efficiency was halved.

2 points	

7. The pole placed as depicted on the figure has one end on the ground, the other end leaning against the wall. What is the necessary condition for the pole not to slip onto the ground?
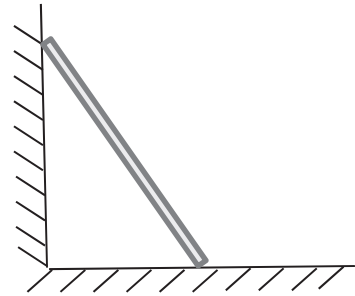
A) The pole can remain in equilibrium only if there is friction both at the wall and at the ground.

B) The pole may remain in equilibrium also if there is friction only at the wall.

C) The pole may remain in equilibrium also if there is friction only at the ground.

D) The pole may remain in equilibrium even if friction is negligible everywhere.

2 points

8. Five identical light bulbs are connected in the circuit depicted on the figure and constant voltage is applied between the two endpoints. Which of the numbered light bulbs shines the brightest?
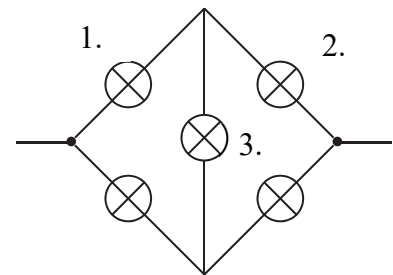
A) Number 1.
B) Number 2.
C) Number 3.
D) Numbers 1 and 2.

2 points

9. In laboratory *A,* 1500 g of ammonia must be heated from a temperature of 22 °C to 37 °C. In laboratory *B,* 3000 g of ethyl alcohol must be heated from a temperature of 12 °C to 42 °C. The specific heat capacity of ammonia is approximately twice as much as the specific heat capacity of ethyl alcohol. In which laboratory is more energy required to heat the material?

A) In laboratory *A* is more energy required.
B) In laboratory *B* is more energy required.
**C)** The same amount of energy is required in the two laboratories.

2 points

10. **A slab is floating at the boundary of two liquids with different densities, layered on top of each other. One fourth of the slab's volume is immersed in the liquid on top, while three-fourths is immersed in the liquid which is beneath. What can we say about the density of the slab?**

    A) The slab's density is the arithmetic mean of the liquids' densities, because the slab is floating.
    B) The slab's density is greater than the arithmetic mean of the liquids' densities.
    C) The slab's density is less than the arithmetic mean of the liquids' densities.
    D) Based on the data, we cannot make a statement about the slab's density. From the result it only follows that the density of the lower liquid is three times the density of the upper liquid.

2 points

11. **Electrons are emitted with varying initial speed from the cathode depicted on the figure, which are then accelerated further by voltage *U*. Electrons with average velocity reach the photographic plate at a distance *x* from the pinhole *A*. Where do electrons with greater than average speed reach the photographic plate?**
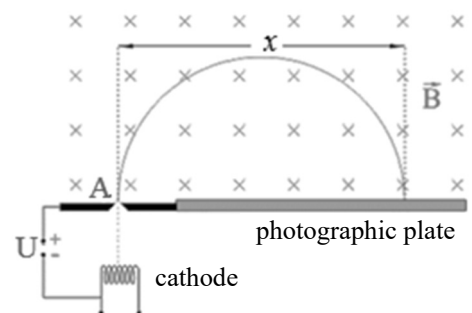
    A) Electrons with speeds greater than average reach the photographic plate at a distance greater than *x* from the pinhole.
    B) Electrons with speeds greater than average reach the photographic plate at a distance smaller than *x* from the pinhole.
    C) Electrons with speeds greater than average reach the photographic plate at a distance equaling *x*, because the trajectory radius depends only on the charge to mass ratio.

2 points

12. **We place a metal plate on top of a coil with vertical axis and an iron core and subsequently connect the coil to alternating current. The frequency of the alternating current is 30 Hz. With what frequency will the metal plate begin to oscillate?**

    A) 60 Hz.
    B) 15 Hz.
    C) 30 Hz.

2 points

13. We illuminate a metal with an 800 nm wavelength, 5 mW power laser source, which causes the emission of *N* photoelectrons per second. How many photoelectrons will be emitted from the same metal per second if it is illuminated with a 400 nm wavelength, 10 mW power laser source?

    A) N .
    B) $2N$.
    C) $N/2$.
   **D)**   It s not possible to determine using the information given.

2 points	

14. The wavelength of blue light in vacuum is 430 nm, that of red light is 620 nm. Two students are performing optical experiments. One of them determines the wavelength of blue light in air with index of refraction $n_a = 1.0003$, the other measures the wavelength of red light in glass with index of refraction $n_g = 3/2$. Is it possible for the second student to measure the wavelength of red light to be shorter than the wavelength of blue light measured by student one?

    A)   No, it is not possible. The wavelength of red light is always greater than that of blue light, because the frequency of red light is always less than that of blue light.
    B)   Yes, it is possible, but then the colour of red light will be blue.
    C)   Yes, it is possible because the wavelength of light depends on its velocity in a given medium.
    D)   No, it is not possible because the speed of red light and blue light is always equal in any medium.

2 points	

15. The adjacent photograph depicts a crater on the Moon. How was it created?
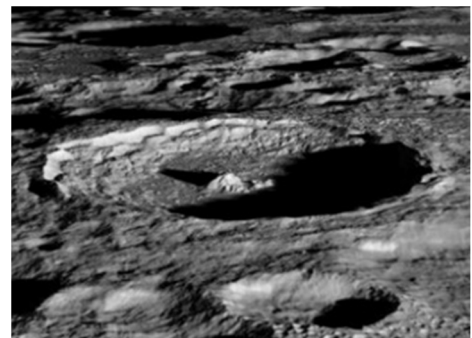
    A)   It was created by the impact of a meteorite.
    B)   It was created by a volcano still active on Moon today.
    C)   It is not possible to determine from the picture.

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. Artificial light and sleep

Sleep is controlled by a hormone called melatonin in our bodies, which is produced only in the dark. When light dawns in the morning, the production of the hormone stops, which serves as a natural wake-up call for our bodies. This process that controls our biological clock is easily disrupted, however, if someone is exposed to excessive amounts of light during the night, especially if it is the 450-500 nm wavelength blue light. Using light sources like this at night leads to insomnia. For this reason, modern mobile phones can change the screen lighting according to the time of the day. The graph on the left shows the wavelength distribution of natural light reaching our eyes (originating from the Sun) at noon and around sunset. The graph on the right shows the distribution of light emitted by a mobile phone in daylight mode and night mode.

(Based on the article "Among artificial light sources" by Alexandra Fazekas. Élet és Tudomány 2018/39. Illustrations by Ádám Egri.)
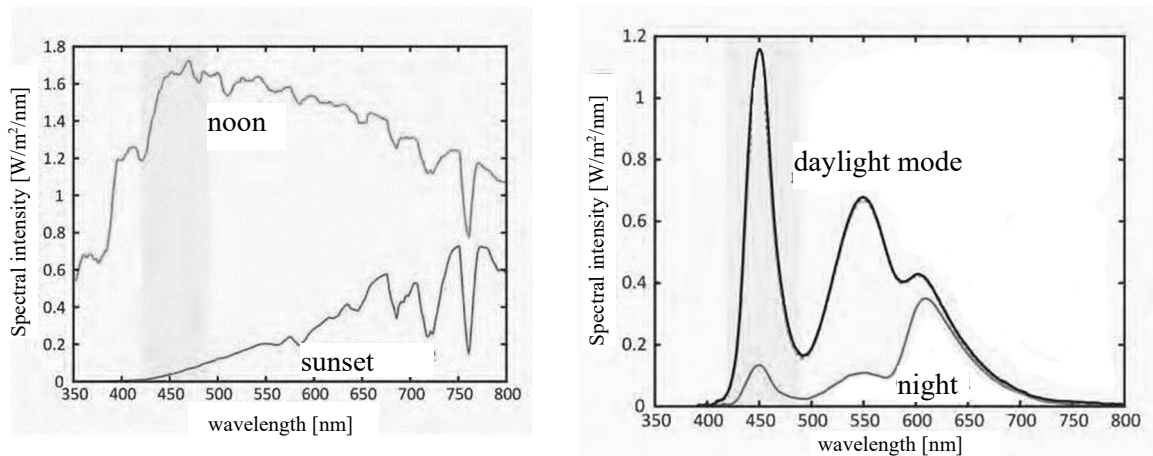
a) Review the physical quantities that characterize waves, give their definition, symbol, physical unit and the most important relationships between them.
b) What is the frequency range of visible light?
c) How can white light be decomposed into components? Name a method and explain the physical process behind it.
d) Compare the wavelength distribution curves of natural light with the experience that the Sun at noon looks yellowish, while the setting Sun looks red.

colour	wavelength (nm)
violet	390-420
blue	420-500
green	500-570
yellow	570-590
orange	590-600
red	600-700

e) The daylight mode curve of mobile phone light distribution has three maxima. Compare this measurement result with the information that the colors of pixels are generated by red, green and blue LEDs.

f) Why is it especially harmful to use mobile phones in daylight mode just before going to bed?

g) What is the wavelength of the most intensive component in the light of mobile phone screens in night mode? What colour does that correspond to?

2. The centrifugal governor

The centrifugal governor is a device that can regulate the rotational speed of steam engines to remain constant. The device is connected to the axle of the steam engine by a transmission belt, so if the rotational speed of the steam engine increases, the centrifugal governor also rotates faster whereas if the rotational speed of the steam engine decreases, the rotation of the governor also decreases. The weights ascend or descend depending on the rotational speed and regulate the steam inlet valve through a mechanism of arms and hinges attached to them. If the balls ascend, the valve is closed, if they descend the valve is opened.
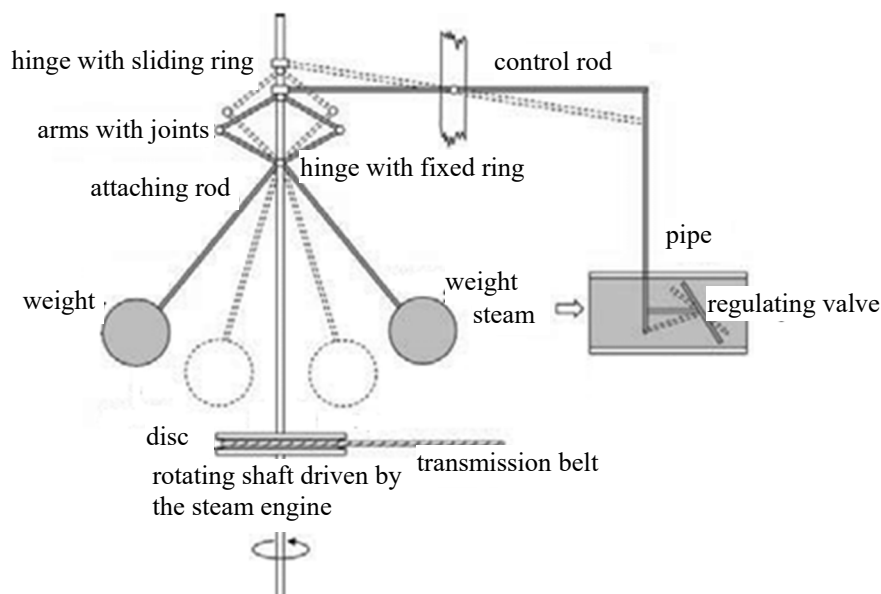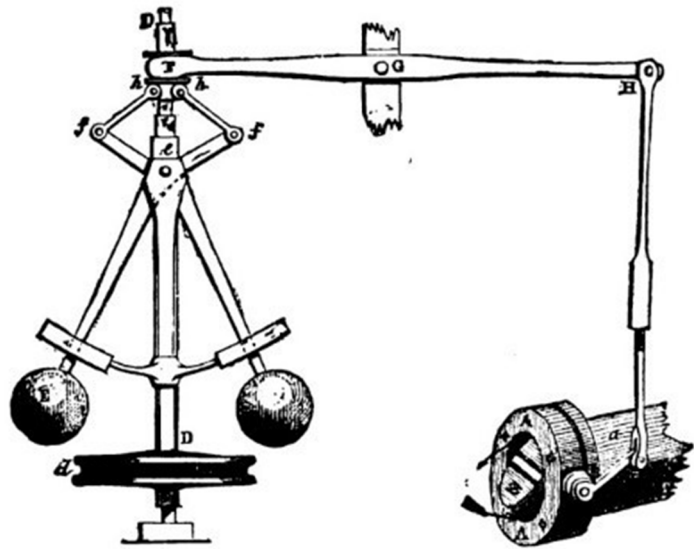
a) Review the meaning of the physical quantities characterizing uniform circular motion, give their definition and the relationships between them (rotational speed, period, angular speed, tangential speed, centripetal acceleration).

b) Explain the dynamical condition of uniform circular motion.

c) Sketch the forces that act on one of the balls of the centrifugal governor on the figure below and explain why the ball ascends when the rotational speed increases.

d) Explain how the device regulates the rotational speed of the steam engine through the hinges, sliding ring and arms. How does it prevent both a too high and a too low rotational speed?
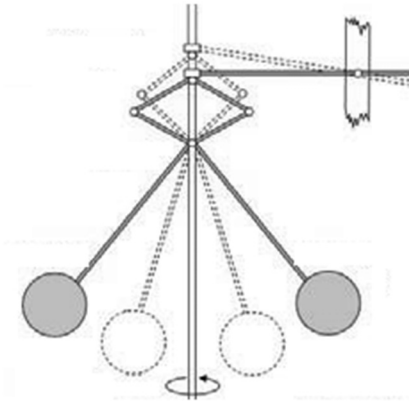
3. The equivalence of mass and energy in practice

Review the structure of the atomic nucleus, the concepts of atomic number, mass number and isotope.

Explain the most important properties of the nuclear (strong) interaction.

Write down and explain the mass-energy equivalence principle.

Review the phenomenon of mass defect. Introduce the concept of binding energy and explain how we can draw conclusions on the binding energy of a nucleus from measurements of mass.

Explain the principle of a particle accelerator.

Introduce the concept of anti-particle and name an example.

Review the phenomenon of pair creation and annihilation.

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 periodic decrease in the luminosity of a star is caused by an exoplanet that passes before it during its orbit and thus blocks part of it periodically. The measured luminosity of the star is plotted on the graph below as a function of time. From other observations we know that the average distance of the planet from its star is $R = 1.5$ billion km and that the trajectory of its orbit is approximately circular.**

(Image: https://www.cfa.harvard.edu/~avanderb/tutorial/tutorial.html)
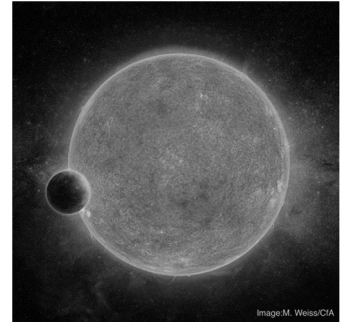
   a) What is the orbital period of the planet?
   b) What is the mass of the star?

$$\gamma = 6.67 \cdot 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}.$$
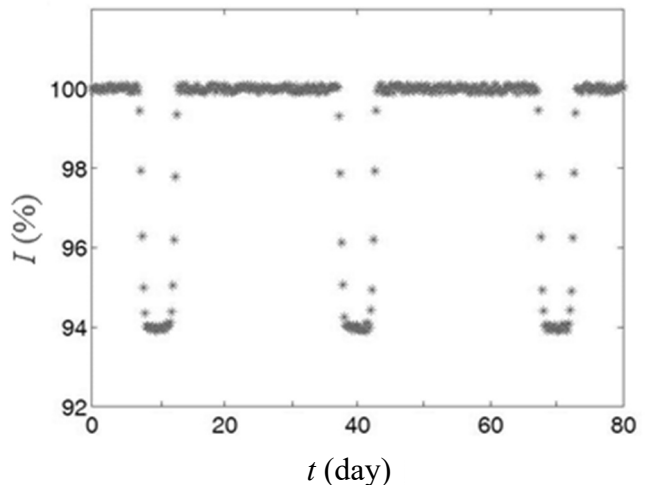
a)	b)	Total
3 points	8 points	11 points

2. **A freezer produces 30 ice cubes with 20 g mass each and a temperature of -18 °C in a time of 1 hour, 20 minutes from 15 °C water placed in it. During this time, its motor draws a 0.5 A current constantly from the 230 V electric outlet. No other object is placed into the freezer to be cooled.**

   a) What is the electric power of the motor?
   b) How much heat is given off by a single ice cube during the whole process?
   c) What is the heating power with which the freezer heats the kitchen?

   The specific heat capacity of water is: C_w = 4200 J/(kg·K), its heat of fusion is: L = 334 kJ/kg, the specific heat capacity of ice is: C_i = 2100 J/(kg·K).

a)	b)	c)	Total
2 points	7 points	5 points	14 points

3. **A small body is started with an initial velocity of $v_0 = 0.6$ m/s on a smooth level surface and it moves with constant deceleration covering a 1 meter long path in 2 seconds.**

    a)   What is the speed of the body at the end of the 1-meter path?
    b)   What is the acceleration of the body?
    c)   What is the coefficient of kinetic friction between the body and the surface?
    d)   What percentage of the body's initial kinetic energy was transformed to heat on the 1-meter long path?

    $g = 9.8$ m/s^2.

a)	b)	c)	d)	Total
3 points	2 points	3 points	4 points	12 points

4. **A pair of wires leading to an electric socket inside the wall developed a short-circuit. The insulation between the wires melted somewhere and the two wires touched. We try to locate the fault (after disconnecting electric power from the electrical network) by measuring the resistance between the two poles of the electric socket. This is found to be 0.05 Ω. The wire in the wall is made of copper, its diameter is 1.6 mm.**

How far is the short-circuit from the point of measurement?

The electrical resistivity of copper is: $\delta = 0.017 \cdot 10^{-6}\, \Omega\, \text{m}$.

Total
10 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**	

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date

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examiner

	pontszáma **egész számra** kerekítve	
	elért	programba beírt
I. Feleletválasztós kérdéssor		
II. Témakifejtés: tartalom		
II. Témakifejtés: kifejtés módja		
III. Összetett feladatok		

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