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Almaty University of Power Engineering & Telecommunications

Department of
Technical Physics

PHYSICS 2

Methodical guidelines for carrying out of CGW
for students of specialty
5B070200 - Automation and control

Almaty 2017

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The methodical guidelines contain variants of tasks for self-studying work of students (CGW) and a sample of their design.
Il. 12, tab. 7, references - 4.

Reviewer: candidate of Chemical sciences, G.S. Ospanova

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Introduction

The main objectives of studying the course "Physics 2" in the higher technical school are to form:

a) general ideas about the modern physical picture of the world;

b) knowledge and skills apply:

- the basic concepts, laws and models of classical and modern physics,
- methods of theoretical and experimental research in physics.

It is known that mastery of knowledge as the most important process of human activity is subject to the laws of psychology:

- development and education for any person can’t be given or communicated. Anyone who wants to develop and master knowledge achieves this through his own work, his own will, his own perseverance and purposefulness;
- successful activity is impossible without the awareness and adoption of the goal of the activity, a clear picture of the results and about the methods and means that are necessary to achieve the goal.

In this guidelines, the CGW variants are presented, divided, as the complexity of their implementation increases, into three levels of mastering knowledge: A, B, and C. The criteria for the separation of tasks are as follows:

- level A tasks are tasks and qualitative questions that require, in the main, the ability to solve problems according to a given pattern;
- level B tasks require the ability to solve typical tasks using a well-known algorithm;
- level C assignments require the ability to identify internal connections in a specific, rather complex, physical situation and apply knowledge of common methods.

Each student independently chooses the level of tasks and gets the number of the option when distributing the group leader. This distribution should be approved by the teacher, who conducts practical work in the group.

Recommendations for mastering the disciplines "Physics 2".

Solving problems while studying the physics course in a technical university is of great importance for future specialists. It teaches us to analyze the phenomena studied, to isolate the main factors, distracting from random and inessential details, and to teach us how to model real physical and physical-technical processes. Tasks develop the skill in using general laws of the material world to solve specific problems that have practical or cognitive significance.

It is impossible to learn to solve problems in physics without knowing and understanding the theory. Therefore, when performing computational and graphical work, it is necessary to work out an independent theoretical material on the topics of the assignment and to assimilate the basic concepts, laws, theorems and principles.

The process of solving the stated physical problem consists, as a rule, of three main stages. At the first, physical stage, the task condition is analyzed, a drawing, diagram or vector diagram is executed for its visual interpretation; Then, on the basis of the relevant laws, a system of equations is compiled, the unknowns of which include the unknown quantities.

At the second, mathematical stage, the solution of the system of equations is found, i.e. get the solution of the problem first in a general form, and then, after performing the calculations, the numerical answer of the problem.

After a general solution is obtained, it is necessary to analyze it. At this third stage, we determine how and from what physical quantities the value found depends, under what conditions this dependence is manifested. When analyzing the numerical response, the dimensionality of the obtained quantity is checked and the plausibility of the answer is estimated, that is, the correspondence of the numerical response to the physically possible values of the sought value.

General requirements for the execution of calculation and graphic works.

Each calculation and graphic work is performed in a separate notebook (school) or typed on the computer. The work should be done accurately, drawings - with a pencil using a ruler. The condition of each task is completely rewritten, without abbreviations, then it must be written using the generally accepted symbolic notation in a concise form under the title "Given". The solution must be accompanied by brief explanations that reveal the meaning of the notation used, where possible, to give a schematic drawing explaining the solution of the problem. It is necessary to indicate what physical laws are at the core of this task, to solve it in general form (in letter designations), then substitute numerical data and perform calculations. It is necessary to indicate units of physical quantities. In the calculations it is recommended to use the rules of approximate calculations and correctly write down the answer.

For the teacher's comments, margins are left on the page.

The work should include a list of used literature.

Information on the cover or title page is given in accordance with the example below.

A sample of the title page:

NPJSC AUPET
Department of Technical Physics
Discipline "Physics 2"
Calculation and graphic work No._, variant _
Completed by student of the group AC-17-3 (last name and first name)
Checked - the post and name of the teacher.
Date of submission of work for assessment.

Example design of a problem solution.

Problem. An electric generator consist of a 100-turn circular coil 50 cm in diameter (the figure 1 shows a rectangular coil). It is rotated at v=50 rev/s to produce standard 50 Hz alternating current. Find the magnetic field B, needed for a peak output voltage of 310 V (which is the actual peak in our standard 220-V household wiring).

Given:

N=100 turns;
d=0.50 m;
ν= 50 rev/s;
U_{max}=310 V.

Find:
B

Solution:

Here we have a conducting coil rotating in a stationary magnetic field, so the changing of flux through this coil is a result of a changing its orientation. With a uniform field and flat, circular area, the magnetic flux through one turn of coil is

$$\Phi_1 = B\frac{\pi d^2}{4}\cos\alpha.$$

The angle α changes as the coil rotates. We need to express the total magnetic flux as a function of time. Because the loop rotates with constant angular speed $\omega = 2\pi\nu$, its angular position is $\alpha = \omega t = 2\pi\nu t$. Then the magnetic flux through each turn is

$$\Phi_1 = B\frac{\pi d^2}{4}\cos 2\pi\nu t$$

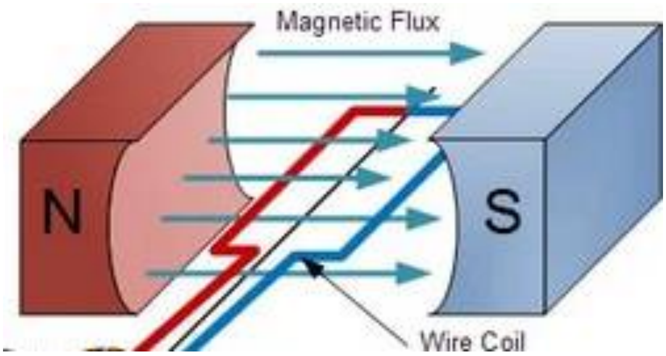

Figure 1

and the total flux is

$$\Psi = NB\frac{\pi d^2}{4}\cos 2\pi\nu t.$$

According to Faraday's law the EMF induced in the coil is

$$\mathcal{E}_i = -\frac{d\Psi}{dt} = 2\pi\nu NB\frac{\pi d^2}{4}\sin 2\pi\nu t.$$

The EMF has its peak value when the sine is 1, so

$$U_{max} = \mathcal{E}_{imax} = 2\pi\nu NB\frac{\pi d^2}{4}.$$

Thus

$$B = \frac{2U_{max}}{\pi^2\nu NBd^2}. = \frac{2\cdot 310}{9.87\cdot 50\cdot 100\cdot 0.25} = 0.050\,T.$$

Answer: B= 50 mT.

The calculation and graphic work № 1

Subject: electromagnetic induction. The Maxwell equations.

Objectives:

- studying the phenomena of electromagnetic induction, its role in the development of the theory of the electromagnetic field, paying special attention to the physical meaning of the Maxwell equations;
- assimilation of the basic concepts and laws of electromagnetism and mastering the methods of their application to the solution of typical problems.

Table 1 - Tasks to the CGW № 1

Level	Variant	Richard Wolfson, Essential University physics, V 2, p. 187-190	College physics, Hugo Young, p. 727-734	Appendix A
A	1	2, 17, 26	9 (p. 727), 4 (p. 729), 21	1
A	2	7, 19, 26	10 (p. 727), 5 (p. 729), 22	2
A	3	8, 15, 52	6 (p. 727), 21, 47	3
A	4	4, 16, 53	7 (p. 727), 22, 47	4
A	5	2, 16, 18, 64	8 (p. 727), 33	5
A	6	7, 15, 19	9 (p. 727), 34, 43	6
A	7	2, 17, 22	10 (p. 727), 32, 44	7
A	8	8, 16, 18	11 (p. 727), 34, 43	8
A	9	2, 14, 19	13 (p. 730), 25, 32	9
B	10	14, 22, 33	27, 48, 1 (p. 728)	10
B	11	7, 26, 35, 59	28, 49	11
B	12	5, 14, 20, 42	29, 50	12
B	13	4, 15, 21, 32	30, 51	13
B	14	25, 37, 66	47, 56, 15 (p. 729	14
B	15	28, 38, 60	46, 52, 14 (p. 729)	15
B	16	8, 29, 59	45, 53, 13 (p. 729)	16
B	17	2, 32, 51	44, 57, 12 (p. 729)	17
B	18	30, 50, 61	43, 58, 11 (p. 729)	18
B	19	33, 39, 60	42, 59, 2 (p. 728)	19
B	20	34, 47, 53	37, 60, 3 (p. 728)	20
B	21	2, 32, 65	36, 63, 4 (p. 728)	21
B	22	31, 41, 67	35, 24, 5 (p. 728)	22
B	23	33, 47, 55	34, 25, 6 (p. 728)	23
B	24	43, 64, 58	33, 19, 8 (p. 728)	24
B	25	30, 56, 68	32, 18, 9 (p. 728)	25
B	26	47, 49, 66, 58	20, 31	26

C	27	65, 71, 73, 14 (p. 235), 35 (p. 236)	19	27
C	28	31, 68, 34(236), 66	20, 60	28
C	29	47, 65, 34 (236), 68	19	29
C	30	66, 71, 14(235), 35 (236)	20	30

Note: the page numbers in parentheses.

Appendix A

A.1 A flat conducting frame rotates in a uniform magnetic field. Whether the EMF is induced in the frame if the axis of rotation lying in the plane of the frame is a) parallel to the lines of induction; b) is perpendicular to the magnetic field lines?

A.2 Explain, which force drives electric charges in the conducting circuit, in which the EMF is induced by a variable in time magnetic field. The contour is fixed relative to the field.

A.3 Figure A.1 shows flat contours of thin wires that are in a uniform magnetic field that are directed perpendicular to the plane of the drawing "to us". The field began to increase. Determine the direction of the induction currents in the circuits.

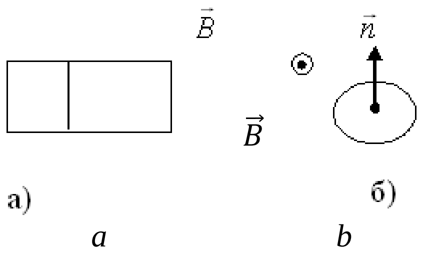

Figure A.1

A.4 A metal loop moves at constant velocity toward a long wire carrying a steady current (figure A.2). Find the direction of inducing in the loop current.

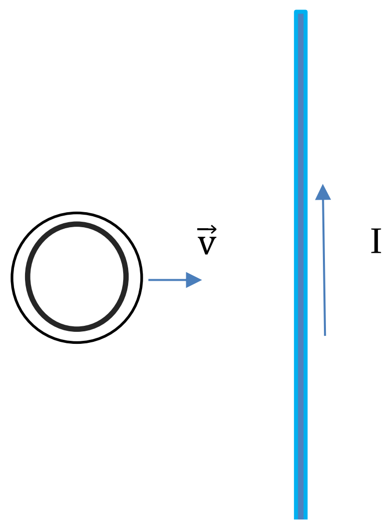

Figure A.2

A.5 A metal rod fixed at one end can freely oscillate in the absence of a magnetic field, but in a magnetic field its oscillations rapidly decay. Why? Where does this phenomenon find application?

A.6 There is a vertically placed inductor on which the metal object lies. Why does this object get heated if an alternating current flows through the turns of the cc and remains cold at a constant current?

A.7 Wind the solenoid, laying turns in one layer close to each other. How does the ratio of the inductance of the solenoid to the resistance of the winding L/R change with the number of turns? The solenoid is considered long.

A.8 A circular conducting plane contour is placed in a homogeneous magnetic field, perpendicular to the field lines. Specify the direction of the current arising in the circuit in the following cases: a) the contour is

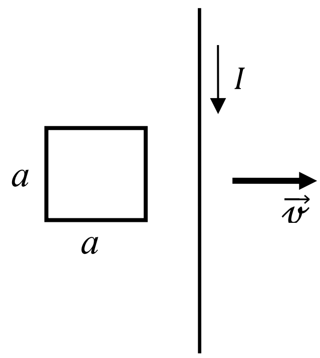

Figure A.3

stretched; b) the contour is compressed.

A.9 In figure A.3, the conductor with current I moves to the right with the speed $\vec{v}$. How does the current flow in a fixed conducting circuit in the form of a square frame with side a, the plane of which lies in the plane of the forward current I? What determines the magnitude of the induction current in the frame?

A.10 Does the inductance of the toroidal coil with the iron core depend on: a) the current in the winding? b) the temperature of the core?

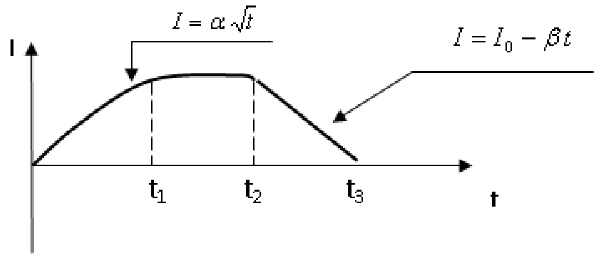

Figure A.4

A.11 A current flows through the inductor L, the time dependence of which is shown in figure A.4, where α and β are constants. Construct qualitatively the graph of the dependence of the EMF of self-induction in the coil, indicate the nature of the dependence.

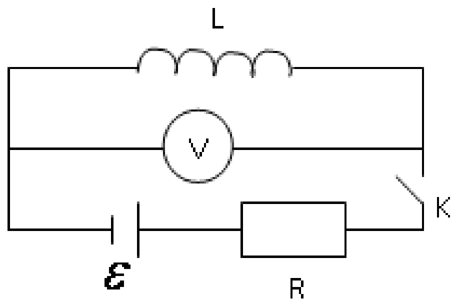

Figure A.5

A.12 In the circuit shown in figure A.5, at the instant of time t = 0 the circuit is closed. Construct qualitatively the plots of the current I in the circuit and the voltage U on the voltmeter versus the time t (the resistance of the coil is neglected).

A.13 In a magnetic field of an infinitely long forward current I, a conductor of length l with velocity v moves in a direction perpendicular to the current (figure A.6). The conductor l is always parallel to the current I in one plane with it. Find the potential difference at the ends of the conductor l as a function of its position relative to the wire with the current. Under what condition will this potential difference remain constant all the time?

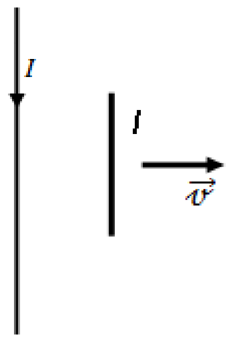

Figure A.6

A.14 Two round turns (not electrically connected) are located one after another, and you look along the line connecting their centers. The battery is connected to the near coil, and the current flows in a counter-clockwise direction. a) In what direction will the induction current flow in the far turn? b) How long does it last? c) How will the duration of the induction current change if the diameter is doubled: wires; turns?

A.15 What physical magnitude did J.C. Maxwell call the displacement current, why? What is the density of the displacement current? What direction does the vector $\vec{j}_D$ have?

A.16 The important conclusion made by J.K. Maxwell, we can formulate this: in nature, all electric currents are closed. How should this be understood? Explain.

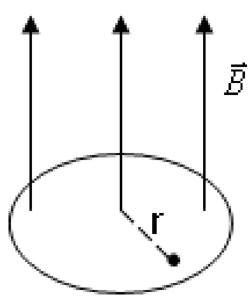

Figure A.7

A.17 What is the electromagnetic field? Give the definition. What equations reflect the physical structure of the electromagnetic field?

A.18 Can an electric field with closed lines of force exist in any area of space? If so, under what circumstances?

A.19 In a homogeneous magnetic field $\vec{B}$, the flux of which is limited by a circular cross section *S*, at a distance *r* from the axial flow line there is a α-particle (figure A.7). The field *B* decreases uniformly. How will the α-particle behave in this case?

A.20 How do I reel the coil (solenoid) so that its inductance *L* is very small?

A.21 In the plane of the rectilinear conductor with current *I* there is a conductive frame (figure A.8). The current in the conductor varies according to the law $I \sim t^2$, with the force acting on the frame, $F \sim t^k$. Find the value of *k*.

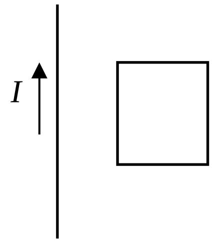

Figure A.8

A.22 The magnetic flux through the area of the conducting ring increases uniformly. Show that the intensity of the vortex electric field in the ring is proportional to its radius.

A.23 Show that in a homogeneous medium, in the absence of external charges and currents, a uniform alternating magnetic field generates an inhomogeneous electric field.

A.24 The current in the winding of the toroidal coil with an iron core doubled. Is it true that in this case: a) the magnetic field inside the solenoid doubled; b) the energy of the magnetic field enclosed in the solenoid increased fourfold; c) did the inductance of the solenoid remain unchanged?

A.25 A homogeneous magnetic field $\vec{B}$ is created in space. Indicate in the figure the direction of the lines of the vortex electric field $\vec{E}$ in the following cases: a) the magnetic field increases with time; B) the magnetic field decreases with time. Determine the condition under which the electric field modulus will not depend on time.

A.26 The conducting circuit is taken out of the inter-polar space of the electromagnet. What depends on the time the contour is moved a) the amount of heat released in the circuit; b) a charge flowing along the contour?

A.27 Aluminum objects, as a rule, are not attracted to a magnet. If the aluminum disk (which can rotate) is located under the horseshoe magnet and unscrews the magnet, the disc will also start rotating. Why? Which way will the disk rotate? (the speedometer of the car works on this principle).

A.28 Show that in a homogeneous medium, in the absence of external charges and currents, a uniform alternating electric field generates an inhomogeneous magnetic field.

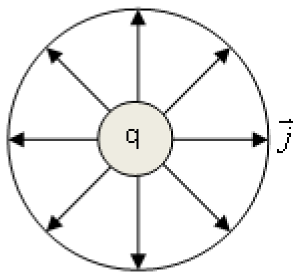

Figure A.9

A.29 What is the essential difference between the Maxwell and Faraday understanding of the phenomenon of electromagnetic induction? Whose interpretation of the law is more general? Why?

A.30 Let an metallic sphere be placed in an unbounded conducting medium, to which the charge *q* is given (figure A.9). Since the medium is conductive, electric currents flowing in radial directions will appear, but there will be no magnetic field in the surrounding space. Prove it.

The calculation and graphic work № 2

Subject**:** oscillations and waves.

Objectives:

- studying parallel mechanic and electric oscillations and waves, paying attention to their similarity and difference, characteristics and equations;
- learning the graphical method of representing a harmonic oscillation with the help of a rotating amplitude vector (phasor diagram);
- mastering the basic concepts and laws of the physics of oscillations and waves, mastering the methods of their application to the solution of typical problems associated with calculating the parameters of oscillatory systems, wave characteristics of electromagnetic radiation.

Table 2 - The tasks for the CGW № 2

Variant	Wolfson, Richard, V.2	Young, Hugo/ College physics	Ohanian, Hans	Appendix B
1	48(298)	26(361); 34(361); 34(403); 14(758)		1
2	22(297)	27(361); 57(363); 15(758); 35(896)		2
3	23(297)	39(362); 12(758); 36(896)	32(499)	3
4	25(297)	42(362); 3(758); 37(896)	33(499)	4
5		3(401); 48(362); 4(758); 38(896)	34(499)	5
6		45(362); 10(758); 10(401)	35(499)	6; 13
7	53(298)	26(361); 11(758)	37(499)	7; 11
8	54(298)	27(361); 12(758)	38(499)	8;12
9	60(298)	39(362); 14(758); 57(363)		9; 13
10	48(298) 29(519)	16(759); 15(895)	22(498) 77(502)	10
11	30(519)	28(361); 4(401); 25(759)	23(498) 80(503)	11
12	31(519)	30(361); 26(759); 12(401); 34(896)	27(498)	12
13	32(519)	34(361); 13(758); 7(796); 15(895)		13; 17
14	49(520)	33(361); 32(760); 8(796); 34(896)		14;18
15	50(520)	31(361); 21(759); 13(796)	45(1062)	8; 15
16	69(298)	32(361); 41(760); 36(896)	79(502)	10; 16
17	53(520)	37(362); 57(363);17(759); 12(796)	44(1062)	17
18	49(520)	30 (361);11(401); 51(363); 18(759); 40(896)		18
19	50(520)	41(362); 40(760); 15(796);35(896)	45(1062)	19

20	49(520)	29(361); 36(362);12(401); 16(796)	79(502)	20
21	53(520)	33(361); 50(362); 17(759); 15(796)		9; 21
22	50(520); 42(534)	38(362); 39(760); 15(796)	44 (1062)	22
23	51(534)	31(361); 37(760); 17(796)	45(1062)	10; 23
24	67(271); 49(534)	36(760); 25(797); 12(401)	44 (1062)	24;
25	55(298); 44(534)	28(361); 52(363); 32(760); 22(797)		25
26	65(271); 42(534)	35(760); 17(796)	45(1062)	21; 26
27	77(272); 68(521)	61(363); 14(758); 40(896)		23; 27
28	59(520)	31(361); 37(362); 61(363); 42(760); 41(896)		28
29	63(271); 56(520); 82(299)	28(759); 28(759); 42(896)		29
30	69(271); 54(520)	60(363); 61(363); 24(759); 44(896)		30

Note: the page numbers in parentheses.

Appendix B

B.1 - B.10 A point performs a combination of two harmonic oscillations of the same frequency, occurring at mutually perpendicular directions and expressed by equations, which are shown in table B.1. Find the equation of the trajectory of a material point, build it to scale and indicate the direction of motion.

Table B.1

1	2	3	4	5
$x = 2\cos\omega t$ $y = 2\cos\omega t$	$x = 2\cos\omega t$ $y = 3\cos\omega t$	$x = 2\cos\omega t$ $y = 2\cos(\omega t + \frac{\pi}{2})$	$x = \cos\omega t$ $y = 2\cos(\omega t + \pi)$	$x = 3\cos\omega t$ $y = 3\sin\omega t$

6	7	8	9	10
$x = 2\cos\omega t$ $y = 3\sin\omega t$	$x = \sin\omega t$ $y = 3\sin\omega t$	$x = \sin\omega t$ $y = 2\sin(\omega t + \pi)$	$x = 2\cos\omega t$ $y = 3\cos(\omega t - \frac{\pi}{2})$	$x = 3\cos\omega t$ $y = 2\sin\omega t$

B.11 Damped oscillations occur in accordance with $x(t) = 0{,}03e^{-7t}\sin 7\pi t$ (mm). Find θ the logarithmic decrement of damping.

B.12 Amplitude of damped oscillations of a pendulum for t=2 min decreased twice (halved). Define β a damping coefficient.

B.13 A damped *RLC* circuit includes a 5.0 -Ω resistor and a 100-mH inductor. If half of the initial energy is lost after 15 cycles, what is the C capacitance?

B.14 - B.19 View on the phasor diagram oscillations: a) $x=A_1cos(\omega t+\varphi_1)$, б) $x=A_2\ cos(\omega t\ +\varphi_2)$ at time points $t_1 = 0$ and t_2. Take appropriate numerical values in the table B.2.

Table B.2

№	A_1, cm	A_2, cm	φ_1	φ_2	t_2
14	3,0	5,0	π/6	2π/3	π/(ω)
15	3,0	4,5	π/4	- π/6	π/(2ω)
16	3,0	6,0	π/6	2π/3	π/(3ω)
17	4,0	3,0	- π/6	π/3	π/(ω)
18	4,0	6,0	- π/3	2π/3	π/(2ω)
19	4,0	6,0	- π/3	3π/4	π/(4ω)

B.20 – B.24 View on the phasor diagram at time t = 0, the displacement of the body, vibrating under the law $x=Acos(\omega t+\varphi_0)$, its $\dot{x}$ velocity and acceleration $\ddot{x}$. Take the corresponding numerical values in table B.3.

Table B.3

№	20	21	22	23	24
A, sm	5,0	6,0	7,0	4,0	8,0
φ_0	π/4	π/6	π/3	2π/3	3π/4

B.25 Damped oscillations occur in accordance with $x(t) = 0{,}03e^{-5t}\sin 8\pi t$ (mm). Find the logarithmic decrement of damping θ.

B.26 Amplitude of damped oscillations of a pendulum for t=3 min decreased twice (halved). Define a damping coefficient.

B.27 A damped *RLC* circuit includes a 4.0 -Ω resistor and a 80 -mH inductor. If half of the initial energy is lost after 12 cycles, what is the capacitance?

B.28 The circuit consists of a capacitor C = 4 μF and coil with inductance L = 2 mH and active resistance R = 10 ohms. Find the ratio of the magnetic energy of the coil to the electric energy of the capacitor in time points, when current is maximum. What in these times is self-induction EMF in the coil?

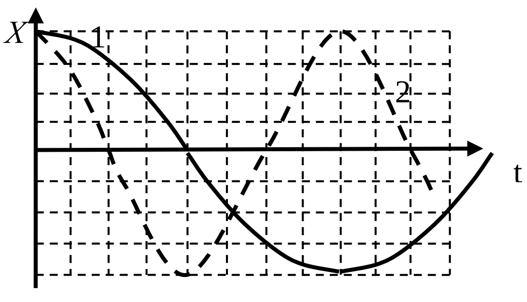

Figure B.1

B.29 The circuit consists of a capacitor capacitance C = 4 μF, coil with inductance L = 2 mH and resistor R = 10 ohms. Find the ratio of the energy of the magnetic field of the coil to the energy of the electric field of capacitor in the time points, when current is maximum. What in these times is the ratio between the voltage across the coil and the potential difference across the plates of the capacitor?

B.30 Figure B.1 shows the graphs of two harmonic oscillations. The first of them is described by the equation $x=A\cos(\omega t+\varphi_0)$. Write down the equation of the second oscillation, assuming that the quantities A and ω are known. Which of the oscillations has the most energy W, how many times?

The calculation and graphic work № 3

Subject: The quantum physics. Physics of the Atomic Nucleus

Objectives:

- assimilation of quantum concepts about the nature of electromagnetic radiation, on the basis of which the laws of thermal radiation, the photoelectric effect, and the Compton effect can be explained;
- clarification the universal nature of particle-wave dualism; The physical meaning of the uncertainty relations as a quantum limitation of the applicability of the notions of classical mechanics; the necessity of specifying the state of the micro particle by means of the wave function;
- understanding the nature of the differences in the properties of electrical conductivity of metals, semiconductors and dielectrics; physical essence of fission reactions of heavy nuclei and thermonuclear reaction;
- formation of skills to apply conservation laws in the transformation of atomic nuclei and elementary particles.

Table 3 - The tasks to the CGW № 3

Variant	Wolfson, Richard/ Essential University Physics, V. 2	Young, Hugo/ College physics	Ohanian, Hans	Appendix C
1	15(357); 80(360)	2(964); 1(1044); 5(1044)	42(1283)	1
2	16(357)	3(964); 41(968); 3(1044); 12(1044)	43(1283)	2
3	17(357); 30(357)	6(964); 4(1044)	44(1283) 33(1390)	3
4	18(357)	13a(964); 40(968); 1(1045)	45(1283) 34(1390)	4
5	19(357); 80(360)	9(965); 2(1045)	44(1283) 35(1390)	5
6	16(357); 24(357)	44(968); 14(1044); 3(1045)	43(1283)	6
7	17(357); 30(357); 24(557)	5(964); 15(1044)	47(1283)	7
8	18(357); 24(357)	14(968); 45(968); 1(1045)	42(1283)	8
9	19, 24 and 30		43(1283)	9

	(357); 15(549); 27(557)			
10	33(357); 38 and 53(358)	1(1000); 4(1045)	47(1283);	10
11	34(357); 41 and 45(358); 31(557)	6a,b,c(1045)		11
12	19 and 35(357); 40(558)	4(964); 1(1000); 7(1045)		12
13	39, 46 and 67(358); 39(558)	1(1000)	19(1389)	13
14	18 and 33(357); 49(358)	1(1000)	21(1389)	14; 20
15	38 and 44(358); 24(557)	47(968); 20a,b,c(966)	22(1389)	15
16	36, 41 and 53 (358); 25(557); 42(558)		23(1389)	16
17	39 and 50(358); 27(557); 50(559)	49(968)	24(1389)	17
18	39, 48 and 51 (358); 74(359)	20a,b,c(966)	26(1389)	18
19	35(357); 46(358); 75(359)	7(1045); 20a,b,c(966)	36(1390)	19
20	38, 45 and 65 (358); 39(558)	47(968)	37(1390)	20
21	41, 42, 52 and 66 (358); 40(558)		38(1390)	21
22	49 and 67 (358); 38(550); 74(359)		39(1390)	15; 22
23	50 and 62(358); 75(359); 18(549)		40(1390)	13; 23
24	38, 51 and 65 (358); 38(550)	20a,b,c(966)	38(1390)	24
25	23(357); 39, 52 and 66 (358); 36(549)		39(1390)	25
26	22(357); 41 and 53(358)	49(968)	48(1317); 40(1390)	26
27	58(358); 72 and 74(359)		45(1317); 28(1389); 41(1390)	27
28	59(358); 73 and 75(359)		46(1317); 29(1389)	23; 28

29	60(358); 74 and 76(359)		47(1317); 30(1389)	29
30	58(358); 75, 77 and 79(359); 77(560)	21(967)		30

Note: the page numbers in parentheses.

Appendix C

C.1 – C.9 What is called α-decay? Indicate its main regularities. Write down the equation for the α-decay of the nucleus ^{A}X. The chemical element designation and mass number are given in table C.1. What physical quantities persist in radioactive transformations?

Table C.1

№	1	2	3	4	5	6	7	8	9
Nuclear	^{238}U	^{234}Th	^{230}Th	^{226}Ra	^{222}Rn	^{218}Po	^{210}Po	^{212}Bi	^{210}Bi

C.10 What is called α-decay? Indicate its main regularities. Write down the equation for the α-decay of the nucleus ^{60}Co. What physical quantities persist in radioactive transformations? Will the characteristics of the daughter nucleus change after it emits a γ-quantum?

C.11 What is called β-decay? What types of β-decay are distinguished? Indicate their main regularities. What physical quantities persist in radioactive transformations? Consider, for example, the electronic decay of the thorium isotope Th with a mass number *A*= 234. Will the characteristics of the daughter nucleus change after it emits a γ-quantum?

C.12 What is called β-decay? What types of β-decay are distinguished? Indicate their main regularities. What physical quantities persist in radioactive transformations? Consider, for example, the positron decay of a nitrogen isotope ^{13}N. Will the characteristics of the daughter nucleus change after it emits a γ-quantum?

C.13 What is called β-decay? What types of β-decay are distinguished? Indicate their main regularities. What physical quantities persist in radioactive transformations? Consider, for example, the positron decay of an isotope ^{137}Cs. Will the characteristics of the daughter nucleus change after it emits a γ-quantum?

C.14 What is called β-decay? What types of β-decay are distinguished? Indicate their main regularities. What physical quantities persist in radioactive transformations? Consider, for example, the electronic decay of the isotope ^{133}Sb. Which isotope is formed from it after four such β-decays?

C.15 What process is called electron capture? Indicate their main regularities. What physical quantities persist in radioactive transformations? Consider, for example, the electron capture of a potassium nucleus with a mass number *A* = 40.

C.16 Express the de Broglie wavelength of a relativistic particle of mass *m* through it: a) the velocity *v*; B) the kinetic energy *T*. At what velocity *v* is the particle its Compton wavelength λ_C is equal to the de Broglie wavelength λ_B?

C.17 What is the "saturation current" of a photocell? How does the saturation current of a given photocell depend: (a) on the magnitude of the light flux, (b) on the intensity of the electric field in the incident light wave? Construct the graphs of these dependencies (qualitative).

C.18 How will the type of the current-voltage characteristic of a photocell change, if: a) with a constant spectral composition of the wave, its total luminous flux will double; B) with a constant light flux, the frequency of monochromatic light will double? Draw the characteristics on the chart and explain them.

C.19 How will the type of the current-voltage characteristic of a photocell change if the frequency of monochromatic light increases (decreases) twofold with an unchanged photon flux? Draw the characteristics on the chart and explain them.

C.20 What is the difference between a conductor (metal) and a semiconductor in terms of the band theory of solids?

C.21 What is the difference between a semiconductor and a dielectric in terms of the band theory of solids?

C.22 Figure C.1 depicts a plot of the spectral density of the energy luminosity $r_{\lambda,T}$ (emissivity) of a black body as a function of the wavelength λ. In this graph, two sections are distinguished, different in width ($\Delta\lambda_1$ and $\Delta\lambda_2$) , whose areas under the curve are equal ($\Delta S_1 = \Delta S_2$). Compare the average emissivity r_1 and r_2, as well as the energy luminosities ΔR_1 and ΔR_2 in the intervals $\Delta\lambda_1$ and $\Delta\lambda_2$, respectively. Is it true that the numbers of emitted quanta are equal $\Delta N_1 = \Delta N_2$?

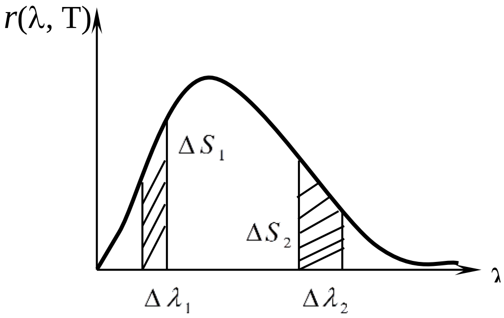

Figure C.1

C.23 What is the essence of the tunneling effect? Why it is impossible within the framework of classical mechanics? Explain. Specify the phenomena that serve as experimental proof of the passage of microparticles through the potential barrier. Define the transparency coefficient *D* of the potential barrier and explain which parameters of the system it depends on. Does the law of conservation of energy contradict the passage of a particle with kinetic energy *W* through a potential barrier of height *U* under the condition $W<U$? Show how you can solve this problem using the uncertainty relation.

C.24 As a result of Compton scattering in one case, the scattered photon flew at an angle θ_1 to the original direction, and in the other case - at an angle $\theta_2 > \theta_1$. In what case is the radiation wavelength after scattering larger and in what case the recoil electron received more energy?

C.25 What is the Compton effect? Show that the laws of the Compton effect can be explained only on the basis of corpuscular ideas about electromagnetic radiation. Why is the Compton effect called "playing billiards with photons and electrons"? Explain why the Compton effect is not observed in the scattering of visible light?

C.26 What are *fermions* and *bosons*? Why are fermions called "individual sheets", and bosons - "collectivists"? Are there other classes of particles?

C.27 Explain the appearance of negatively charged particles in the positive nucleus in beta minus decay.

C.28 Explain the appearance of positron in the nucleus in beta plus decay.

C.29 Explain from the point of view of the band theory why divalent metals (aluminum, copper, beryllium, etc.) are good conductors, although their valence bands are completely filled. Show schematically the structure of the electronic energy spectrum of these metals.

C.30 Describe the main properties of alpha decay from the point of view of the energy of the α-particles inside and outside the nucleus. How does α-particle overcome a potential barrier whose height exceeds the total energy α-particles?

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Content

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