Oliy o‘quv yurtlariga kiruvchilar uchun

FIZIKA

MA'LUMOTNOMA

Kitob shu yerda ko'rsatilgan muddatdan kechiktirilmagan holda topshirilishi shart

Ilgarigi berilmalar miqdori__________	

K.A. TURSUNMETOV, M. PO‘LATOV

FIZIKA

Umumta'lim maktablari, akademik litsey, kasb-hunar kollejlari o‘quvchilari hamda oliy o‘quv yurtlariga kiruvchilar uchun

TOSHKENT
«O‘ZBEKISTON»
2016

UO‘K 53(075)
KBK 22.3ya7
T 97

Taqrizchilar:
U. Abdurahmonov, O‘zMU professori,
N. Zikrillayev, TDTU professori

Mazkur kitobda fizika fanining barcha mavzulari amaldagi o‘quv dasturiga muvofiq ravishda qisqacha yoritilgan. Fizikadan testlar va masalalar yechish uchun zarur bo‘lgan formulalar, grafiklar hamda asosiy qonunlarning ta’riflari keltirilgan.

Qo‘llanma oliy o‘quv yurtlariga kiruvchilar fizikani qisqa muddatda takrorlashlari yoki ularni qayta tayyorlash uchun hamda olimpiadaga tayyorgarlik ko‘rayotgan maktab hamda akademik litsey va kasb-hunar kollejlarining o‘quvchilari uchun mo‘ljallangan.

ISBN 978-9943-28-701-3

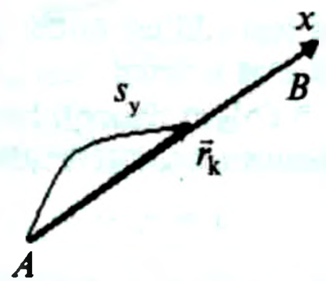
I bob. MEXANIKA

1.1. Mexanik harakat

Mexanika fizika fanining bir bo‘limi bo‘lib, u materiya harakatining eng oddiy ko‘rinishlari – jismlarning bir-biriga nisbatan ko‘chishlarini o‘rganadi. Biror jismning fazodagi vaziyatini boshqa jismlarga nisbatan vaqt bo‘yicha o‘zgarish jarayoni **mexanik harakat** deyiladi.

Qo‘yilayotgan masalada o‘lchamlarini hisobga olmaslik mumkin bo‘lgan jism **moddiy nuqta** (yoki **nuqta**) deyiladi.

Nuqtaning harakati davomida chizib qoldirgan izi **harakat trayektoriyasi** deyiladi.



Agar trayektoriya to‘g‘ri chiziq bo‘lsa, **to‘g‘ri chiziqli harakat**, egri chiziq bo‘lsa, **egri chiziqli harakat** deyiladi.

Nuqta harakat trayektoriyasining uzunligi **yo‘l** deb ataladi, ya’ni $s_y = \breve{AB}$. Nuqtaning boshlang‘ich va oxirgi vaziyatini tutashtiruvchi va harakat yo‘nalishini ko‘rsatuvchi vektor $\vec{r}_k = \overline{AB}$ **ko‘chish** deyiladi.

Vaqt birligida bosib o‘tilgan yo‘l (ko‘chish) **tezlik** deyiladi.

Trayektoriyaning ma’lum nuqtasidagi yoki berilgan vaqt momentidagi tezlik **oniy tezlik** deyiladi.

Juda kichik vaqt intervalida $s_y \approx r_k$ va oniy tezlik:

$$\upsilon = \lim_{\Delta t \to 0} \frac{\Delta s_y}{\Delta t} = \lim_{\Delta t \to 0} \frac{\Delta r_k}{\Delta t} \left(\text{yoki} \quad \vec{\upsilon} = \frac{d\vec{r}}{dt}\right).$$

Nuqtaning vaziyatini koordinatalar (sonlar)da ifodalash uchun koordinatalar sistemasi ishlatiladi, chunki nuqtaning berilgan vaqt momentidagi vaziyatining koordinatalarini aniqlash mexanikaning asosiy vazifasidir.

Jismning harakati boshqa bir jismga nisbatan o'rganiladi. Ana shu boshqa jism **sanoq jism** deyiladi.

Sanoq jism va unga biriktiriladigan koordinatalar sistemasi hamda vaqt sanog'i birgalikda **sanoq sistemasi** deyiladi.

Sanoq sistemasi → Inersial sanoq sistemasi — bir-biriga nisbatan to'g'ri chiziqli tekis harakat qiladi, ya'ni $\vec{v}$ = const, yoki tinch holatda bo'ladi.

Sanoq sistemasi → Noinersial sanoq sistemasi — bir-biriga nisbatan tezlanish bilan harakat qiladi, ya'ni $\vec{v} \neq$ const.

To'g'ri chiziqli harakatda ko'chish (yo'l) bilan koordinata orasidagi bog'lanish

$$x = x_0 + r_x \quad \text{yoki} \quad x = x_0 + r_x = x_0 + v_x t,$$

bu yerda: x_0 — nuqtaning boshlang'ich koordinatasi; x — berilgan vaqt momentidagi koordinatasi; v_x — tezlikning x o'qi bo'yicha proyeksiyasi.

$v_x = \dfrac{\Delta x}{t} = \dfrac{\Delta s}{t}$ — vaqt birligida bosib o'tilgan yo'l (ko'chish) — tezlik.

Tezlik komponentalari:
$$\left.\begin{aligned} v_x &= \frac{\Delta r_y}{\Delta t} = \frac{x - x_0}{\Delta t}, \\ v_y &= \frac{\Delta r_y}{\Delta t} = \frac{y - y_0}{\Delta t}, \\ v_z &= \frac{\Delta r_z}{\Delta t} = \frac{z - z_0}{\Delta t}. \end{aligned}\right\}$$

$$\Delta\vec{r} = \Delta r_x \cdot \vec{i} + \Delta r_y \cdot \vec{j} + \Delta r_z \cdot \vec{k} \quad \text{va} \quad \Delta r = \sqrt{\Delta r_x^2 + \Delta r_y^2 + \Delta r_z^2}$$

$$\text{yoki} \quad \Delta s = \sqrt{\Delta s_x^2 + \Delta s_y^2 + \Delta s_z^2}.$$

Tezlik vektori:

$$\vec{v} = v_x \cdot \vec{i} + v_y \cdot \vec{j} + v_z \cdot \vec{k} \quad \text{va} \quad v = \sqrt{v_x^2 + v_y^2 + v_z^2}.$$

Tezlanish vektori:

$$\vec{a} = a_x \cdot \vec{i} + a_y \cdot \vec{j} + a_z \cdot \vec{k} \quad \text{va} \quad a = \sqrt{a_x^2 + a_y^2 + a_z^2}.$$

1.2. To‘g‘ri chiziqli tekis harakat

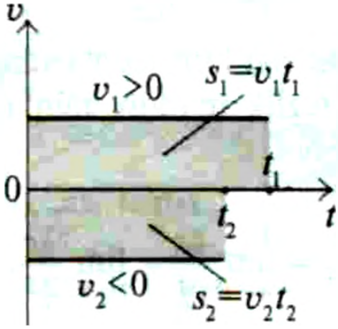
Trayektoriyasi to‘g‘ri chiziqdan iborat bo‘lib, tezligi vaqt bo‘yicha o‘zgarmaydigan (v = const) harakat **to‘g‘ri chiziqli tekis harakat** deyiladi, yoki bir xil vaqt intervallarida bir xil ko‘chadigan harakati **to‘g‘ri chiziqli tekis harakat** deb ataladi.

1. Tezlik tenglamasi va grafigi:

$$v = \frac{r}{t} = \frac{s}{t} \quad (\text{chunki } |\vec{r}| = s) \quad \text{yoki} \quad \vec{v} = \frac{\vec{r}}{t} = \text{const}.$$

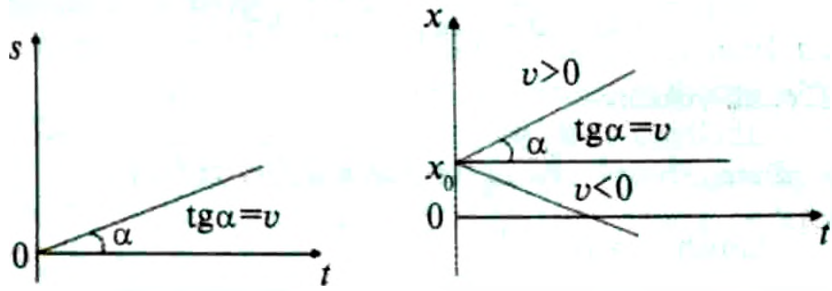
Birligi:

SI da $[v]$ = m/s;
SGS da $[v]$ = sm/s;
texnikada $[v]$ = km/soat.



2. Yo'l (ko'chish) tenglamasi va grafigi:

$s = v \cdot t$ (yoki $\vec{r} = v \cdot t$).



3. Harakat X o'qi bo'ylab ro'y bersa, u holda $s = s_x = x - x_0$ va $v = v_x$ bo'lib, jismning ixtiyoriy vaqt momentidagi koordinatasining tenglamasi $x = x_0 + s_0 = x_0 + vt$ va grafigi rasmdagi ko'rinishda bo'ladi.

1.3. To'g'ri chiziqli notekis harakat

Bir xil vaqt intervallarida moddiy nuqta har xil ko'chsa (har xil yo'l bosib o'tsa), bunday harakat **notekis harakat** deb ataladi.

Umumiy bosib o'tilgan yo'lning (ko'chishning) shu yo'lni bosib o'tilishi uchun ketgan umumiy vaqtga nisbati **o'rtacha tezlik** deyiladi:

$$v_{o'r} = \frac{s_{um}}{t_{um}}.$$

Trayektoriyaning ma'lum nuqtasidagi yoki berilgan vaqt momentidagi tezlik moddiy nuqtaning **oniy tezligi** deb ataladi:

$$v_{on} = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \lim_{\Delta t \to 0} \frac{\Delta r}{\Delta t}.$$

1.4. To‘g‘ri chiziqli tekis o‘zgaruvchan harakat

Trayektoriyasi to‘g‘ri chiziqdan iborat bo‘lib, tezligi bir xil vaqt intervallarida bir xil kattalikka o‘zgaradigan harakat to‘g‘ri chiziqli **tekis o‘zgaruvchan harakat** deyiladi. Tezlikning vaqt birligida o‘zgarishi **tezlanish** deyiladi.

1. Tezlanish tenglamasi:

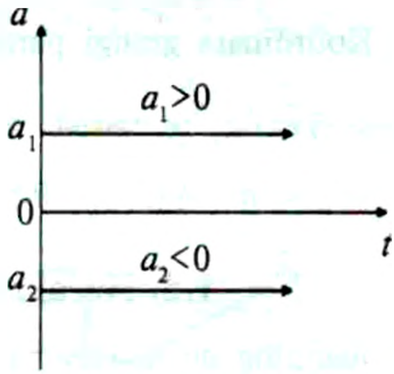
$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}-\vec{v}_0}{t} = \text{const},$$

$a > 0$ — tekis tezlanuvchan, $a < 0$ — tekis sekinlanuvchan harakat.

Tezlanish birligi:

SI da $[a] = \text{m/s}^2$,

CGSda $[a] = \text{sm/s}^2$.



Tezlanish grafigi.

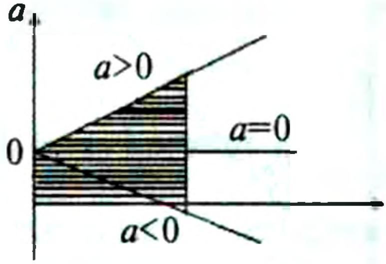
2. Tezlik tenglamasi (tezlikning oniy kattaligi):

$$\vec{v} = \vec{v}_0 + \vec{a}t.$$

Shtrixlangan yuza son jihatdan yo‘l (ko‘chish)ga teng, ya’ni, $s_x = x - x_0$ ga teng.

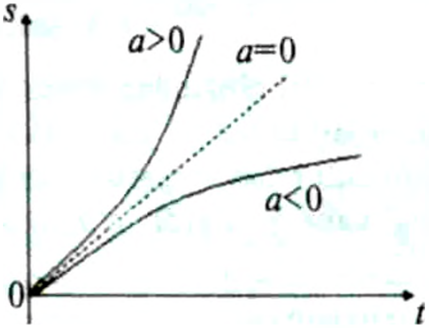
$$s = v_0 t + \frac{at^2}{2}.$$

Agar boshlang‘ich tezlik $v_0 = 0$ bo‘lsa, $s = \frac{at^2}{2}$.



Tezlik grafigi.

3. Yo'l grafigi:



4. Koordinata tenglamasi (harakat X o'qi bo'ylab ro'y berganda):

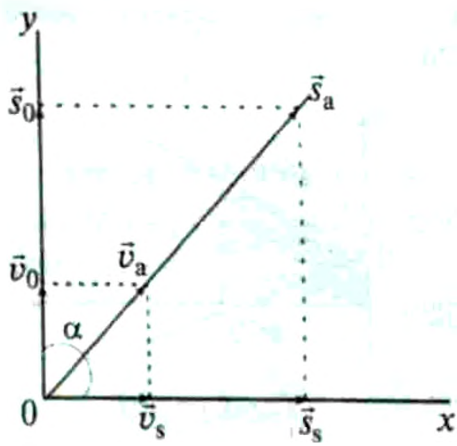
$$x = x_0 + s_x = x_0 + \upsilon_0 t + \frac{at^2}{2}.$$

Koordinata grafigi parabola ko'rinishida bo'ladi.

5. Tezlik, tezlanish va yo'l orasidagi bog'lanish: $\upsilon^2 - \upsilon_0^2 = 2as$. Agar $\upsilon_0 = 0$ bo'lsa, $\upsilon^2 = 2as$ yoki $\upsilon = \sqrt{2as}$.

1.5. Harakatlarni qo'shish

Jismning qo'zg'aluvchan sanoq sistemasiga nisbatan harakati **nisbiy harakat**, qo'zg'almas sanoq sistemasiga nisbatan harakati **absolut (mutlaq) harakat** deyiladi.



Suzuvchining daryodagi harakati misolida natijaviy (absolut) harakat tezligi

$$\vec{\upsilon}_a = \vec{\upsilon}_0 + \vec{\upsilon}_s$$

va ko'chishi

$$\vec{s}_a = \vec{s}_0 + \vec{s}_s,$$

bu yerda: $\vec{v}_0$ — suzuvchining suvga (qo'zg'aluvchan) sanoq sistemasiga nisbatan nisbiy tezligi va s_0— nisbiy ko'chishi; $\vec{v}_s$ — qo'zg'aluvchan sanoq sistemasining (suvning) qo'zg'almas sanoq sistemasiga (qirg'oqqa) nisbatan nisbiy tezligi va s_s — ko'chishi.

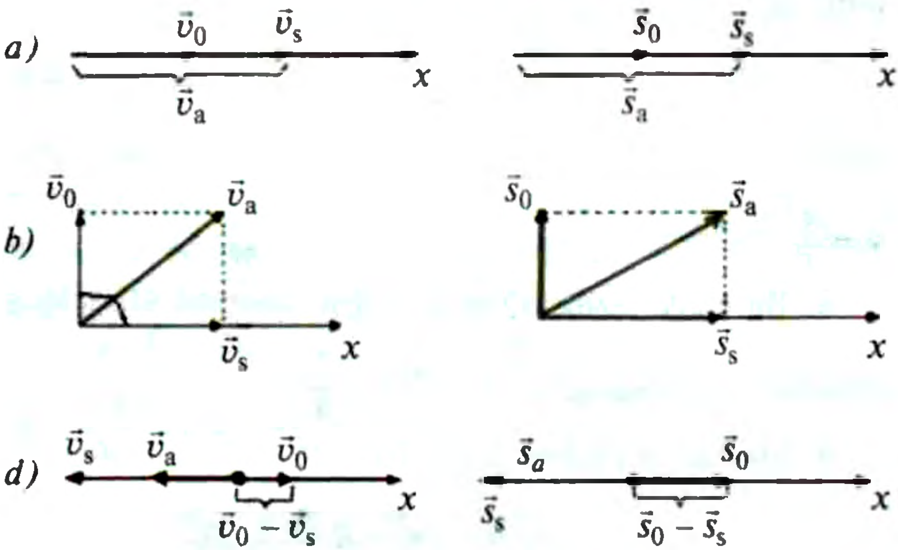
Har bir harakat mustaqil bo'lgani uchun $s_0=v_0t$ va $s_s=v_st$ hamda $s_a=v_at$, u holda $s_a=v_at$. Agar tezliklar orasidagi burchak α bo'lsa, kosinuslar teoremasiga asosan:

$$v_a = \sqrt{v_0^2 + v_s^2 + 2v_0 \cdot v_s \cdot \cos\alpha} \text{ va } s_a = \sqrt{s_0^2 + s_s^2 + 2s_0 \cdot s_s \cdot \cos\alpha}.$$

Agar a) $\alpha = 0°$ bo'lsa, $v_a=v_0+v_s$ va $s_a=s_0+s_s$;

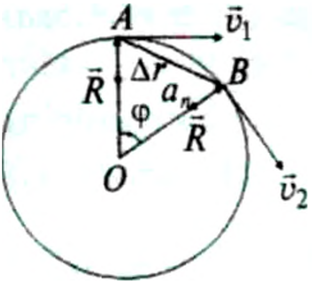
b) $\alpha = 90°$ bo'lsa, $v_a = \sqrt{v_0^2 + v_s^2}$ va $s_a = \sqrt{s_0^2 + s_s^2}$;

d) $\alpha = 180°$ bo'lsa, $v_a=v_0 - v_s$ va $s_a=s_0 - s_s$.



1.6. Aylana bo'ylab tekis harakat

Trayektoriyasi aylanadan iborat bo'lib, tezligi vaqt bo'yicha o'zgarmaydigan harakat **aylana bo'ylab tekis harakat** deyiladi.



1. Yo'l $\Delta s = \overset{\smile}{AB} = \Delta\varphi \cdot R$ – yoyning uzunligi va ko'chish $\Delta\vec{r} = \overline{AB}$.

2. $\Delta t \to 0$ да $\Delta s \approx \Delta r$.

3. Tezlik $\upsilon = \upsilon_1 = \upsilon_2 =$ const va $\upsilon = \dfrac{\Delta s}{\Delta t} = \dfrac{\Delta\varphi \cdot R}{\Delta t}$.

4. Burilish burchagi $\Delta\varphi$ ning Δt ga nisbati $\dfrac{\Delta\varphi}{\Delta t} = \omega$ burchak tezlik deyiladi.

5. $\upsilon = \dfrac{\Delta\varphi}{\Delta t} \cdot R = \omega R$, chunki $\Delta s = \overset{\smile}{AB} = \Delta R \cdot \Delta\varphi$.

6. Aylanish davri $T = \dfrac{t}{N}$ (N — berilgan t vaqtdagi aylanishlar soni) — bir marta to'la aylanish uchun ketgan vaqt.

7. Aylanish chastotasi $\nu = \dfrac{N}{t}$ — vaqt birligidagi aylanishlar soni. $\nu = \dfrac{N}{t}$ — vaqt birligidagi aylanishlar soni. $\nu = \dfrac{1}{T}$.

8. Burchak tezlik bilan aylanish davri va chastotasi orasidagi munosabatlar: $\omega = 2\pi\nu = \dfrac{2\pi}{T}$.

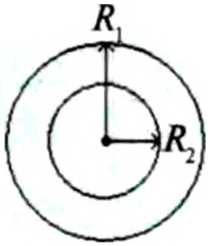
9. Markazga intilma tezlanish:

$$a_n = \frac{\upsilon^2}{R} = \omega^2 R = 4\pi^2\nu^2 R = \frac{4\pi^2}{T^2} R.$$

10. Markazga intilma tezlanish bilan tezlik orasidagi bog'lanish: $a_n = \omega\upsilon$.

11. Markazga intilma tezlanish tezlik vektori yo'nalishining o'zgarishini xarakterlaydi (tavsiflaydi) va u aylana markaziga radius bo'ylab yo'nalgandir.

12. Aylanma o'zaro harakatlar.



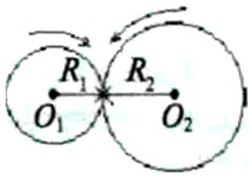
1) Ikkita (bir nechta) bir o'qqa o'rnatilgan jismlarning aylanma harakatida $\omega_1 = \omega_2$ bo'ladi. U holda

$$\frac{v_1}{R_1} = \frac{v_2}{R_2} \Rightarrow \frac{R_2}{R_1} = \frac{v_2}{v_1};$$

2) agar ikkita jism bitta tasma (zanjir)da harakat qilsa, $v_1 = v_2$ bo'ladi. Friksion uzatishda ham $v_1 = v_2$. Bu hollarda

$$\omega_1 R_1 = \omega_2 R_2 \Rightarrow \frac{\omega_1}{\omega_2} = \frac{R_2}{R_1};$$

3) tishli g'ildiraklarda harakatning uzatilishi. Agar tishli g'ildiraklar radiuslari R_1 va R_2, tishlari soni mos ravishda N_1 va N_2 bo'lsa, u holda g'ildiraklarning tishlari orasidagi masofa $d_1 = d_2$ bo'ladi. Shu sababli,

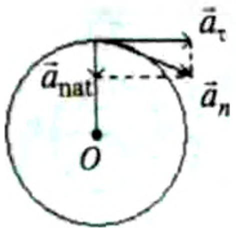


$d_1 = \frac{2\pi R_1}{N_1}$ va $d_2 = \frac{2\pi R_2}{N_2}$ bo'lgani uchun

$$\frac{2\pi R_1}{N_1} = \frac{2\pi R_2}{N_2} \Rightarrow \frac{N_2}{N_1} = \frac{R_2}{R_1}.$$

Tishli uzatishda $v_1 = v_2$ bo'lgani uchun $\frac{\omega_1}{\omega_2} = \frac{N_2}{N_1}$.

13. Aylana bo'ylab tekis o'zgaruvchan harakat. Bu holda oniy burchak tezlik $\omega = \omega_0 + \varepsilon t$ bo'ladi, bu yerda



$\varepsilon = \frac{\Delta\omega}{t} = \frac{\omega - \omega_0}{t}$ – burchak tezlanish va uning birligi $[\varepsilon]$=rad/s^2, ω_0 – boshlang'ich burchak tezlik.

Harakat boshlanganidan t vaqtdan so'ng burilish burchagi $\varphi = \omega_0 t + \frac{\varepsilon t^2}{2}$.

Aylanishlar soni $N = \frac{\varphi}{2\pi} = \frac{1}{2\pi}\left(\omega_0 t + \frac{\varepsilon t^2}{2}\right)$.

Chiziqli tezlikning o'zgarishi tangensial tezlanish bilan tavsiflanadi: $a_\tau = \varepsilon R$.

Natijaviy tezlanish $\vec{a}_{nat} = \vec{a}_n + \vec{a}_\tau$ yoki $a_{nat} = \sqrt{a_n^2 + a_\tau^2}$, bu yerda $a_n = \omega^2 R$ – markazga intilma (normal) tezlanish.

1.7. Erkin tushish

Jismning bo'shliqda (vakuumda, Yerning tortish kuchi ta'sirida) Yer tomon harakati **erkin tushish** deyiladi.

a) 1. *Erkin tushish tezlanishi planeta sirti yaqinida* ($h \approx 0$):

$a = g = \gamma \frac{M}{R^2}$ va h balandlikda

$$g_h = \gamma \frac{M}{(R+h)^2} = g \frac{R^2}{(R+h)^2};$$

$\gamma = 6,67 \cdot 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$ – gravitatsion doimiy; bu yerda R – planeta radiusi.

Yer uchun $g \approx 9{,}81$ m/s^2, ya'ni $\vec{a} = \vec{g} = \text{const}$ $(h \ll R$ da).

2. Tezlik $\vec{v} = \vec{v}_0 + \vec{g}t$ va $v_0 = 0$ bo'lgani uchun $\vec{v} = \vec{g}t$.

Ko'chish (yo'l) $h = \Delta y = v_0 t + \dfrac{gt^2}{2}$ va $v_0 = 0$ bo'lgani uchun $h = \dfrac{gt^2}{2}$.

3. Koordinata tenglamasi: $y = y_0 - h = y_0 - \dfrac{gt^2}{2}$.

Erkin tushishda tezlik:

$$v^2 - v_0^2 = 2gh, \quad v_0 = 0 \text{ da } v = \sqrt{2gh}\,.$$

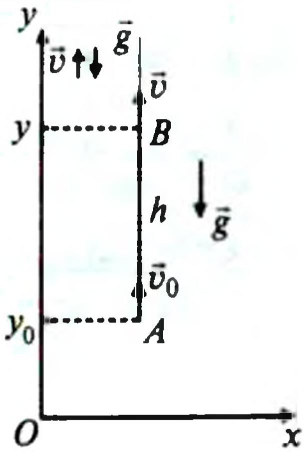
b) *Osmonga tik otilgan jismning harakati.*

1. Tezlanish $\vec{a} = -\vec{g} = \text{const}$ (chunki $\vec{a} \uparrow\downarrow \vec{v}$).
2. Tezlik $v = v_0 - gt$.
3. Ko'chish (ko'tarilish balandligi) $h = v_0 t - \dfrac{gt^2}{2}$.
4. Koordinata tenglamasi:

$$y = y_0 + h, \; y = y_0 + v_0 t - \frac{gt^2}{2}.$$

5. Ko'tarilish vaqti $t_k = \dfrac{v_0}{g}$, chunki A nuqtada $v = 0$.
6. Maksimal ko'tarilish balandligi:

$$h_{max} = \frac{v_0^2}{2g}.$$



7. Tushish tezligi:

8. $t_T = \sqrt{\dfrac{2h_{max}}{g}} = \dfrac{v_0}{g}$ — tushish vaqti.

$t_T = t_k = \dfrac{v_0}{g}$; $t_{um} = t_k + t_T =$

$= \dfrac{2v_0}{g}$ — umumiy harakat vaqti.

1.8. Gorizontga qiyalatib (burchak ostida) otilgan jismning harakati

Harakat murakkab, trayektoriyasi paraboladan iborat bo'lgani uchun uni X va Y o'qlari bo'yicha ajratib o'rganamiz.

1. Tezlikning x tashkil etuvchisi:

$$\upsilon_x = \upsilon_0 \cos\alpha = \upsilon_{0x} = \text{const}.$$

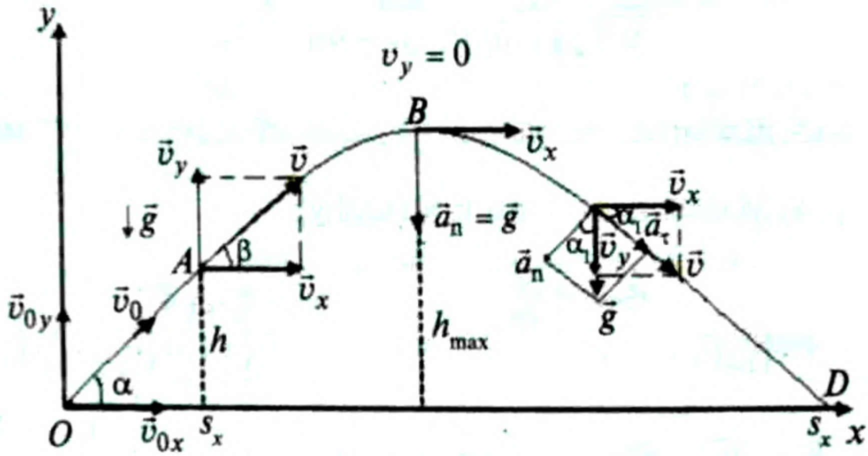
2. Tezlikning vertikal – y tashkil etuvchisi:

$\upsilon_{0y} = \upsilon_0 \sin\alpha$ va $\upsilon_{o'} = \upsilon_0 \sin\alpha - gt$, sababi $\vec{\upsilon}_y \uparrow\downarrow \vec{g}$.

3. Biror vaqtdan so'ng ko'tarilish balandligi:

$$h = \upsilon_0 \sin\alpha \cdot t - \frac{gt^2}{2}.$$

4. Biror vaqtdan so'ng ($t < t_{\text{ko'tarilish}}$) uchish uzoqligi $s_x = \upsilon_0 \cdot \cos\alpha \cdot t$.



5. Trayektoriyaning eng yuqori nuqtasida $\upsilon_y = 0$. $\upsilon_y = \upsilon_0 \sin\alpha - gt_k = 0$. Ko'tarilish vaqti

$$t_k = \frac{\upsilon_0 \sin\alpha}{g}.$$

6. Maksimal ko'tarilish balandligi:

$$h_{max} = H = v_0 \sin\alpha \cdot t_k - \frac{gt_k^2}{2} = \frac{v_0^2 \sin^2\alpha}{2g}.$$

7. Tushish vaqti (BD oraliqda):

$$H = \frac{gt_t^2}{2}; \quad t_t = \sqrt{\frac{2H}{g}} = \frac{v_0 \sin\alpha}{g} = t_k.$$

8. Jismning umumiy uchish vaqti:

$$t_{um} = t_k + t_t = \frac{2v_0 \sin\alpha}{g}.$$

9. Jismning maksimal uchish uzoqligi:

$$s_x = v_x \cdot t_{um} = \frac{2v_0^2 \sin\alpha \cdot \cos\alpha}{g} = \frac{v_0^2 \sin 2\alpha}{g}.$$

10. Ko'tarilish balandligi maksimal, ya'ni

$h_{max} = \dfrac{v_0^2 \sin^2\alpha}{2g} \Rightarrow$ max bo'lishi uchun burchak $\sin\alpha = 1$, $\alpha = 90^\circ$ bo'lishi kerak.

11. Jismning maksimal uzoqlikka uchish burchagi:

$$s_x = \frac{v_0^2 \sin 2\alpha}{g} \Rightarrow \text{max}, \quad \sin 2\alpha = 1. \ \alpha = 45^\circ.$$

12. Markazga intilma tezlanish. Chizmadan

$$\frac{v_0}{v} = \sin\alpha_1 = \frac{a_n}{g}; \quad a_n = \frac{v_x}{v} g.$$

Tezlik $v = \sqrt{v_x^2 + v_y^2}$ bo'lgani uchun $a_n = \dfrac{v_x}{\sqrt{v_x^2 + v_y^2}} g.$

13. Trayektoriyaning egrilik radiusi:

$$a_n = \frac{v^2}{R} \text{ dan } R = \frac{v^2}{a_n}.$$

14. Natijaviy tezlanish:

$$\vec{a}_{\text{nat}} = \vec{g} = \vec{a}_n + \vec{a}_\tau \quad \text{yoki} \quad a_{\text{nat}} = \sqrt{a_n^2 + a_\tau^2}\,,$$

bu yerda a_τ — tangensial tezlanish.

15. Koordinatalarning o'zgarish tenglamalari:

$$\begin{cases} x = x_0 + s_x = x_0 + \upsilon_x t \ \text{yoki}\ x = x_0 + \upsilon_0 \cos\alpha \cdot t \\ y = y_0 + h = y_0 + \upsilon_0 \sin\alpha \cdot t - \dfrac{gt^2}{2}. \end{cases}$$

1.9. Dinamikaning asosiy qonunlari. Nyuton qonunlari

1. Nyutonning I qonuni — inersiya qonuni.

Inersial sanoq sistemalarida jismga boshqa jism ta'sir etmasa yoki ularning ta'siri o'zaro kompensatsiyalansa, jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlaydi.

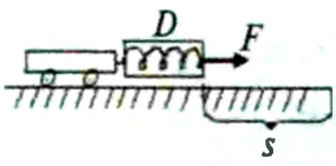
Jismning tezligi $\upsilon = 0$ yoki $\upsilon =$ const.

Tashqi ta'sir bo'lmaganda jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlash xossasiga **inersiya** deyiladi. Shuning uchun Nyutonning I qonuni inersiya qonuni deyiladi.

2. Nyutonning II qonuni. Kuch.

Jismlarning o'zaro ta'sirini xarakterlaydigan fizik vektor kattalikka kuch deb ataladi.

Kuch kattaligi, yo'nalishi va qo'yilishi nuqtasi bilan tavsiflanadi.



Kuch — dinamometr (D) yordamida o'lchanadi.

Tajribadan $a = \dfrac{2s}{t^2}$ har bir Fga mos ravishda aniqlangan. Demak, $a : F$, $a : \frac{1}{m}$ ekan. Bundan $a = \frac{F}{m}$ yoki $\vec{F} = m\vec{a}$ ekan. Bu Nyutonning II qonunidir.

Jismga ta'sir etuvchi kuch uning massasi bilan shu kuch ta'sirida olgan tezlanishning ko'paytmasiga teng.

Kuchning birligi:

SI da $[F] = 1\text{kg} \cdot 1\ \text{m/s}^2 = 1$ N (nyuton);

SGS da $[F] = 1\text{g} \cdot \text{sm/s}^2 = 1$ dn (dina), 1 N = 10^5 dn.

Nyutonning II qonuni quyidagilarni ko'rsatadi:

— qo'yilgan kuch jismning tezlanishini aniqlaydi (belgilaydi);

— kuch — bu jism harakati tezligining o'zgarish sababchisi;

— tezlanishning yo'nalishi kuch yo'nalishi bilan bir xil;

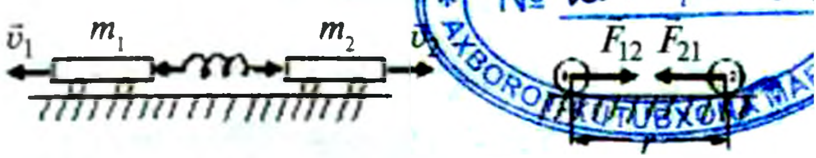
— har qanday kuchlar uchun o'rinli;

— agar jismga bir necha kuch ta'sir qilsa, ularning teng ta'sir etuvchisi olinadi:

$$\vec{F} = \sum_i \vec{F}_i = m\vec{a}.$$

3. Nyutonning III qonuni.

Jismlarning bir-biriga (o'zaro) ta'sir kuchlari o'zaro teng, qarama-qarshi yo'nalgan va bir to'g'ri chiziqda yotadi, ya'ni $\vec{F}_{21} = -\vec{F}_{12}$.



Jismlarning o'zaro ta'sirida tezliklarning o'zgarishi va tezlanishlari:

$$\frac{\Delta v_1}{\Delta v_2} = \frac{m_2}{m_1} \text{ va } \frac{a_1}{a_2} = \frac{m_2}{m_1}.$$

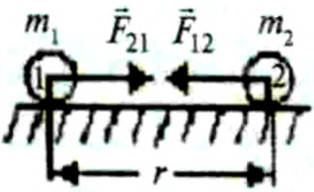
Nyutonning III qonuni:

— jismlarning o'zaro ta'sirlarining barcha hollarida bajariladi;

— o'zaro ta'sir kuchlarining tabiati bir xil.

1.10. Kuchlar

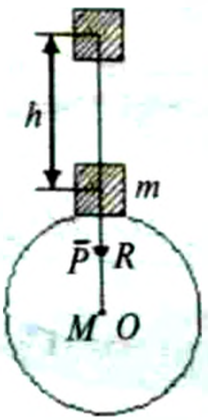
1. Butun olam tortishish qonuni. Barcha jismlar orasidagi o'zaro tortishish kuchlari ularning massalarining ko'paytmasiga to'g'ri proporsional, ular orasidagi masofaning kvadratiga teskari proporsional, ya'ni:



$$F \sim m_1 \cdot m_2 \text{ va } F \sim \frac{1}{r^2},$$

$$F = F_{12} = F_{21} = \gamma \frac{m_1 \cdot m_2}{r^2},$$

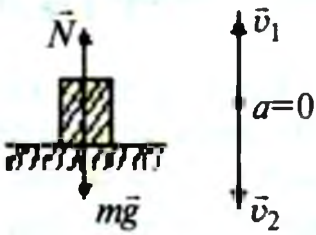
$\gamma = 6{,}67 \cdot 10^{-11}$ $N \cdot m^2/kg^2$ — butun olam tortishish doimiysi (gravitatsion doimiy) — massalari 1 kg dan bo'lgan va orasidagi masofa 1 m bo'lgandagi ikkita jism orasidagi o'zaro ta'sir kuchidir.



2. Og'irlik kuchi. Jismning osmaga yoki tayanchga ta'sir kuchiga og'irlik kuchi yoki jismning og'irligi deyiladi, ya'ni $F = \gamma \frac{m \cdot M}{R^2} = P = mg$. Bu yerda P — og'irlik kuchi, M — Yerning massasi va $g = \gamma \frac{M}{R^2}$ — og'irlik kuchining tezlanishi. Yer sirtida $g \approx 9{,}81$ m/s². h — balandlikdagi jismning og'irligi $P_h = F_h = \gamma \frac{m \cdot M}{(R+h)^2} = mg_h$. Bundan $g_h = \gamma \frac{M}{(R+h)^2} = g \frac{R^2}{(R+h)^2}$ – h balandlikdan og'irlik kuchining tezlanishi.

3. Jismning og'irligi — vazni (harakatdagi vazni) $\vec{P}_h = m\vec{g} + m\vec{a}$.

A) Tayanch tinch holda yoki to'g'ri chiziqli tekis ($a = 0$) harakat qilganda: $P_h = F = mg$, $N = mg = P_h$.



B) Tayanch yuqoriga a tezlanish bilan harakat qilganda $P_h = m(g + a) = N > P$.

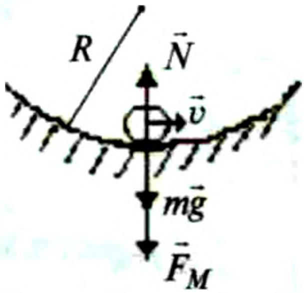
Tezlanuvchan harakati tufayli jismning vaznini oshishi zo'riqish (o'ta yuklanish) deyiladi.

D) Tayanch pastga $\vec{a}$ tezlanish bilan harakat qilganda, $P = m(g - a) = N < P$. Jism $a = g$ tezlanish bilan harakat qilsa, ya'ni erkin tushsa, $P_h = mg - ma = 0$, ya'ni vazni bo'lmaydi. Agar jismlar og'irlik kuchi ta'sirida harakat qilsa, ya'ni erkin tushsa, jismning vazni bo'lmaydi.

4. Jismning sferik sirt bo'yicha harakatidagi vazni.

A) Botiq sirtda:

$$N - mg = F_M = \frac{mv^2}{R}; \quad N = P_h;$$

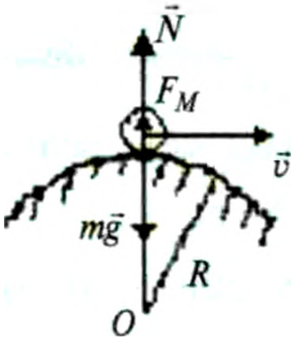


$$P_h = m\left(g + \frac{v^2}{R}\right) = m(g + a_n);$$

$$P_h > mg.$$

B) Qavariq sirtda:

$$mg - N = F_M = \frac{mv^2}{R}; \; N = P_h;$$



$$P_h = mg - \frac{mv^2}{R};$$

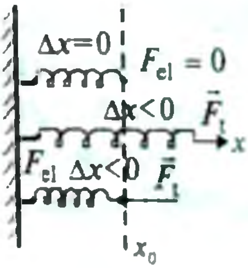
$$P_h = m\left(g - \frac{v^2}{R}\right) = m(g - a_n);$$

$$P_h < mg.$$

1.11. Elastiklik kuchi. Guk qonuni

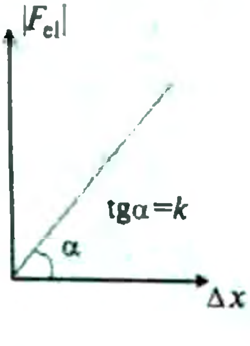
Jismning biror kuch ta'sirida o'zining shaklini yoki o'lchamini o'zgartirish jarayoniga **deformatsiya** deyiladi. Kuch ta'siri to'xtatilgandan so'ng, deformatsiyalanuvchi jism o'zining avvalgi shaklini yoki o'lchamini tiklasa, unday deformatsiya **elastik** (qayishqoq) deformatsiya, tiklamasa, **noelastik** deformatsiya deb ataladi.

Elastik deformatsiya uchun Guk qonuni o'rinli:



$$F_{el} = -k \cdot \Delta x \quad \text{yoki} \quad F_{el} = -k \cdot \Delta l.$$

Bu yerda Δx yoki Δl – absolut deformatsiya kattaligi, k – deformatsiyalanuvchi jismning elastiklik (qayishqoqlik) koeffitsiyenti yoki bikrligi deyiladi va u jism shakliga, o'lchamiga, modda turiga bog'liq.



$k = \dfrac{|F_{el}|}{\Delta x}$ – jismning o'lchamini bir birlikka o'zgartirish uchun kerak bo'lgan kuch yoki vujudga keladigan elastiklik kuchidir.

Birligi: SI da $[k]$ = N/m,
SGS da $[k]$ = dn/sm.

Deformatsiya turlari → Cho'zilish
→ Qisilish
→ Egilish
→ Siljish, buralish

Jism deformatsiyalanganda, ularning tashkil qilgan zarrachalar orasidagi elektromagnit tabiatli kuchlar vujudga keladi va ular jismni avvalgi vaziyati – holatiga qaytarishga harakat qiladi. Shu sababli elastiklik kuchlari elektromagnit tabiatga ega.

Elastiklik kuchlari:

a) deformatsiya natijasida vujudga keladi;

b) ta'sirlashuvchi jism yuzasiga tik yo'nalgan;

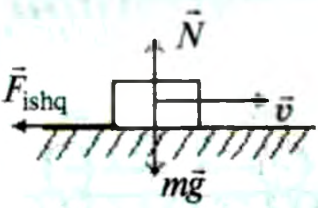
d) tashqi ta'sir etuvchi kuchga qarama-qarshi yo'nalgan;

e) deformatsiya kattaligiga to'g'ri proporsional.

Tayanch yoki osma tomonidan jismga ta'sir qiluvchi kuch **reaksiya kuchi** deb ataladi.

2. Ishqalanish kuchlari.

Jismning boshqa jism yuzasi bo'ylab harakat qilganda vujudga keluvchi va harakatga to'sqinlik qiluvchi kuchlar ishqalanish kuchlari deyiladi.



Ishqalanish kuchlari yuzalarining notekisligi hamda ishqalanuvchi yuzalardagi zarrachalarning o'zaro ta'siri natijasida vujudga keladi.

Ishqalanish turlari → Tinch ishqalanish
→ Sirpanish ishqalanishi
→ Dumalanish ishqalanishi

Ishqalanish kuchlari:

a) bir-biriga tegib turuvchi va nisbatan harakat qiluvchi yuzalarda vujudga keladi;

b) ishqalanuvchi yuzalarga parallel yo‘nalgan;

d) harakat yo‘nalishiga qarama-qarshi yo‘nalgan.

1. Tinch holdagi ishqalanish kuchi $(F_{i.t.})_{max} = \mu N = \mu mg$; μ — ishqalanish koeffitsiyenti, ($P_n = N$—normal bosim kuchi.)

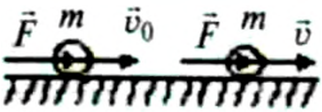
2. Sirpanish-ishqalanish kuchi $F_{i.s.} = \mu mg$ (tekislikda).

3. Dumalanish ishqalanish kuchi sirpanish ishqalanishdan 100÷200 marta kichik. Shuning uchun sirpanish ishqalanishi podshipniklar yordamida dumalanish ishqalanishiga aylantiriladi.

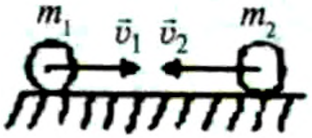
4. Ishqalanishni kamaytirish uchun yuzalar silliqlanadi, ishqalanuvchi yuzalar orasiga suyuqlik — moy kiritiladi.

1.12. Impuls va impulsning saqlanish qonuni

Jismning massasini uning tezligiga ko‘paytmasi jismning **impulsi** yoki harakat miqdori deyiladi.



1. Jismning impulsi $\vec{K} = m\vec{v}$. Birligi: SIda [K] = kg·m/s, SGS da [K] = g·sm/s.



2. F kuch ta’sirida jism impulsining o‘zgarishi $\Delta\vec{K} = \vec{K} - \vec{K}_0 = m\vec{v} - m\vec{v}_0 = \vec{F}\Delta t$ ta’sir etuvchi kuch impulsiga teng.

3. $\vec{F} \cdot \Delta t$ — kuch impulsi, Δt — kuch ta’sir vaqti.

4. Impuls saqlanish qonuni.

Yopiq (izolatsiyalangan) sistemada jismlarning impulslarining vektor yig‘indisi ular o‘zaro ta’sirlashganda ham doimiy qoladi:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{u}_1 + m_2\vec{u}_2 = \text{const}.$$

bu yerda m_1 va m_2 — o'zaro ta'sirlashayotgan jismlarning massalari: v_1 va v_2 — ularning dastlabki, u_1 va u_2 esa ta'sirlashgandan keyingi tezliklari.

5. Absolut (mutlaq) noelastik to'qnashish uchun impuls saqlanish qonuni:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{u}, \text{ chunki}$$

$$u_1 = u_2 = u. \text{ va } \vec{u} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}.$$

6. Jismning o'zidan ajralib chiqqan jismlar yoki zarrachalari bilan o'zaro ta'siri natijasida vujudga keladigan harakat **reaktiv** harakat deyiladi. Reaktiv harakat impuls saqlanish qonuniga binoan ro'y beradi. Masalan, raketa harakati. Uning uchun $m_r\vec{v}_r + m_2 \cdot \vec{v}_2 = \vec{0}$, ya'ni boshlang'ich holat uchun $\vec{K}_{sist} = 0$ Raketa tezligi $v_r = -\frac{m_2 \cdot v_2}{m_r}$; bu yerda $m_2 = \mu \cdot t$; μ esa vaqt birligida ajralib chiqqan yoqilg'i gazining massasi, m_r — vaqt bo'yicha o'zgaradi.

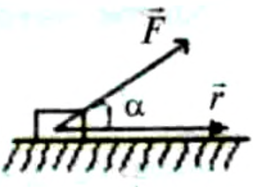
1.13. Mexanik ish. Quvvat

O'zgarmas F kuchning ishi:

$$A = F \cdot r \cdot \cos\alpha \quad \text{yoki} \quad A = (\vec{F} \cdot \vec{r}),$$

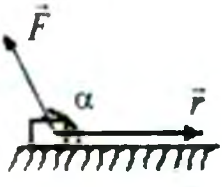
bu yerda r — ko'chish, α — ko'chish va kuch vektorlari orasidagi burchak.

1. Jismga ta'sir etuvchi kuchni, jism ko'chishi, kuch va ko'chish vektorlari orasidagi burchak kosinusining ko'paytmasiga **ish** deyiladi yoki kuch va ko'chish vektorlarining skalyar ko'paytmasiga **ish** deyiladi.

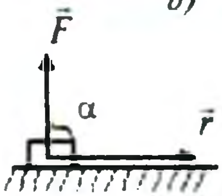


a)

A) agar $0 < \alpha < 90°$ bo'lsa $A > 0$;



b)



d)

B) agar $90° < \alpha \leq 180°$ bo'lsa, $A < 0$;
D) agar $\alpha = 90°$ bo'lsa, $A = 0$.
Birliklari: $[A] = [F]\cdot[r]$.
SI da: 1 J [Joul] = 1 N · 1 m;
1 kJ = 10^3 J; 1 MJ = 10^6 J.
SGS da: 1 erg = 1 dn · 1 sm.
Texnikada: 1 kGm = 1 kG · 1 m = = 9,81 N · 1 m = 9,81 J.

2. Vaqt birligida bajarilgan ish **quvvat** deyiladi.

Quvvat $N = \frac{A}{t}$; $N = \frac{F \cdot r}{t} = F \cdot v$, v — tezlik.

Birligi $1\ \text{W} = \frac{1\ \text{J}}{1\ \text{s}}$. $1\ \text{kW} = 10^3\ \text{W}$; $1\ \text{MW} = 10^6\ \text{W}$,

1 kW · soat = 10^3 W · 3600 s = $3{,}6 \cdot 10^6$ J.

Texnikada: 1 o.k. (ot kuchi) = 75 kG · 1 m/s $\approx \frac{736\ \text{J}}{1\ \text{s}} \approx$ ≈ 736 W, 1 kW $\approx 1{,}36$ o.k.

1.14. Energiya

Jism yoki sistemaning ish bajara olish qobiliyatini tavsiflaydigan fizik kattalik **energiya** deyiladi.

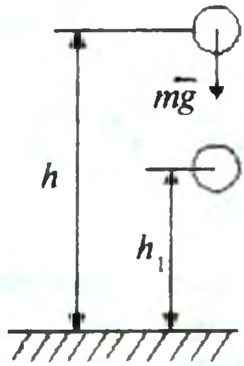
1. Kinetik energiya: $E_k = \frac{mv^2}{2}$; bu yerda m — jism massasi, v — uning tezligi. Jismning harakati tufayli ega bo'lgan energiyasiga **kinetik energiya** deyiladi.

Kinetik energiya haqidagi teorema:

$$A = E_{k2} - E_{k1} = \frac{mv_2^2}{2} - \frac{mv_1^2}{2} \text{ yoki } A = \Delta E_k.$$

Jismning tezligi o'zgarishi natijasidagi kinetik energiyaning o'zgarishi uning bajargan ishiga teng.

2. Potensial energiya.



Jismlarning boshqa jismlar bilan yoki o'zining ayrim qismlari bilan o'zaro ta'siri natijasida ega bo'lgan energiyasiga **potensial energiya** deyiladi.

a) Og'irlik kuchi ta'sir qilayotgan jismning potensial energiyasi: $E_p = mgh$;

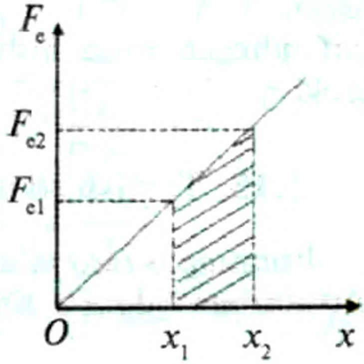
b) og'irlik kuchining ishi:

$$A = mgh - mgh_1 = mg(h - h_1);$$

d) og'irlik kuchining ishi bilan potensial energiya orasidagi bog'lanish:

$$A = E_{p1} - E_{p2} = -(E_{p2} - E_{p1}) = -\Delta E_p.$$

Bu yerda E_{p1} va E_{p2} – jismning h_1 va h_2 balandliklaridagi potensial energiyasi.



Og'irlik kuchining bajargan ishi uning potensial energiyasining kamayishiga teng.

3. Elastik deformatsiyalangan prujinaning potensial energiyasi:

$E_p = \dfrac{kx^2}{2}$; bu yerda k – prujinaning elastiklik koeffitsiyenti (bikrligi), x – deformatsiya kattaligi.

Elastiklik kuchining ishi:

$$A = F_{\text{el.o'rt.}} \cdot (x_2 - x_1).$$

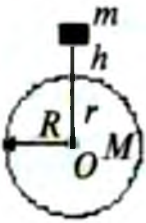
Bu son jihatdan grafikdagi shtrixlangan yuzaga teng:

$$F_{\text{el.o'rt}} = \frac{(-kx_1)+(-kx_2)}{2} = -k\,\frac{x_1+x_2}{2};$$

$$A = \frac{k}{2}\left(x_1^2 - x_2^2\right) = -\left(\frac{kx_2^2}{2} - \frac{kx_1^2}{2}\right) = -\left(E_{p2} - E_{p1}\right) = -\Delta E_p.$$

4. Tortishish maydonidagi jismning potensial energiyasi:

$$E_p = -\gamma\frac{M \cdot m}{r} \quad \text{yoki} \quad E_p = -\gamma\frac{M \cdot m}{R+h};$$



bu yerda M va m — tortishayotgan jismlar massalari, r — ular orasidagi masofa.

5. Mexanik energiyaning saqlanish qonuni.

Yopiq sistema uchun $E_k + E_p = \text{const}$, sistemaning to'liq mexanik energiyasi o'zgarmaydi, bir jismdan ikkinchi jismga uzatiladi, bir turdan ikkinchi turga o'tadi.

6. Mexanizmlarning FIK. Mexanizm va mashinalar ish bajarish jarayonida energiya yo'qotadi va bu energiya qarshilik, ishqalanish kuchlarini yengishga sarf bo'ladi.

Mexanizmlarning FIK: $\eta = \frac{A_f}{A_s} \cdot 100\%$ – foydali ishning sarf qilingan ishga nisbati bilan o'lchanadi. $\eta < 100\%$ (yoki $\eta < 1$).

1.15. Tortishish maydonidagi jism harakati

Jismning o'zaro ta'sirlashuvi, ya'ni biror planetaning tortishish maydoni ta'sirida ega bo'lgan energiyasi potensial energiya deyiladi va $E_p = -\gamma \frac{Mm}{r}$ ga teng bo'ladi.

1. Markaziy tortishish maydonidagi jismning to'la energiyasi: $E_0 = E_p + E_k = \frac{mv^2}{2} - \gamma \frac{Mm}{r}$ va impuls momenti mvr=const. Bu yerda m — harakatlanayotgan jismning massasi, v — harakat tezligi, r — orbita radiusi, M — planeta massasi va $\gamma = 6{,}67 \cdot 10^{-11}\ \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$.

Agar $E_0 < 0$ bo'lsa, harakat trayektoriyasi ellips (aylana) bo'ladi.

Agar $E_0 = 0$ bo'lsa, harakat trayektoriyasi parabola bo'ladi.

Agar $E_0 > 0$ bo'lsa, harakat trayektoriyasi giperbola bo'ladi.

2. Birinchi kosmik tezlik: $\frac{mv^2}{r} = \gamma\frac{Mm}{r^2}$; $v_1 = \sqrt{\frac{\gamma M}{r}}$.

Yer uchun $r \approx R_{Yer}$ bo'lganda

$$v_1 = \sqrt{\gamma\frac{M_{Yer}}{R_{Yer}}} = \sqrt{gR_{Yer}} \approx 7{,}9\ \frac{km}{s}$$

(chunki $g = \gamma\frac{M_{Yer}}{R_{Yer}} \approx 9{,}81\ \frac{m}{s^2}$).

3. Ikkinchi kosmik tezlik ($E_0 = 0$), $E_k = E_n$ shartdan

$$\frac{mv_{II}^2}{2} = \gamma\frac{M_{Yer}m}{R_{Yer}}. \quad v_{II} = \sqrt{2\gamma\frac{M_{Yer}}{R_{Yer}}} \text{ yoki}$$

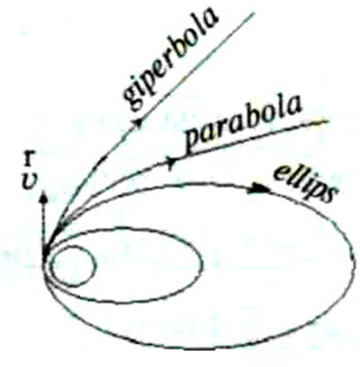
$$v_{II}^2 = \sqrt{2}v_1 = \sqrt{2gR_{Yer}} \approx 11{,}2\ \frac{km}{s}.$$

4. Uchinchi kosmik tezlik: $v_{III} = \sqrt{2}\cdot v_{orb} \approx 42{,}1\ ^{km}/_{s}$,

bu yerda $v_{orb} = 29{,}8\ ^{km}/_{s}$ — Yerning orbital tezligi.

5. Kepler qonunlari (Tixo Bragening kuzatishlariga asosan kashf qilingan):

1) barcha planetalarning orbitalari ellipsdan iborat bo'lib, ularning fokuslarining birida Quyosh yotadi;



2) planetalarning harakati shunday sodir bo'ladiki, Quyosh markazidan planetaga o'tkazilgan radius-vektori teng vaqtlar ichida teng yuzalar chizadi;

3) planetalarning Quyosh atrofidagi aylanish davrlari kvadratlarining nisbati orbita ellipslari katta yarim o'qlarini kublarining nisbatiga teng: $\frac{T_1^2}{T_2^2}=\frac{R_1^3}{R_2^3}$.

1.16. Jismning qiya tekislikdagi harakati

1. Pastga sirpantiruvchi kuch $F_s = mg\sin\alpha$.

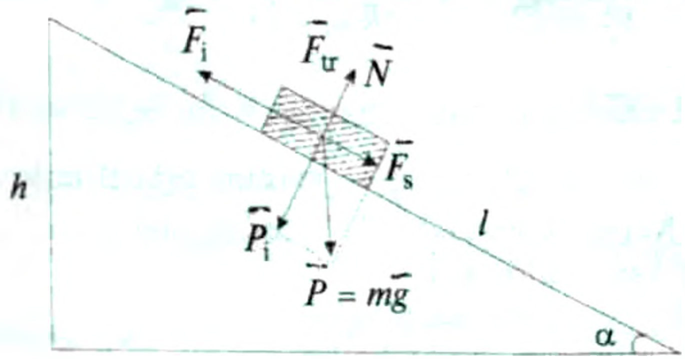
2. Ishqalanish kuchi, $P_i = mg\sin\alpha$ bo'lgani uchun, $F_i = \mu P_i = \mu mg\cos\alpha$, μ — ishqalanish koeffitsiyenti.

3. $F_i \geq F_s$ da jism tinch holatda bo'ladi, ya'ni $\mu\, mg\cos\alpha \geq mg\sin\alpha$, $\mu \geq \operatorname{tg}\alpha$.

4. $F_s \geq F_i$ da harakatlanuvchi kuch

$$F_h = F_s - F_i \quad \text{yoki} \quad F_h = mg(\sin\alpha - m\cos\alpha).$$

5. Harakat tezlanishi: $a = \frac{F_h}{m} = g(\sin\alpha - \mu\cos\alpha)$.



6. Harakat tezligi $v = \sqrt{2as + v_0^2}$, $s = l$ va boshlang'ich tezlik $v_0 = 0$ bo'lsa,

$$v = \sqrt{2gl(\sin\alpha - \mu\cos\alpha)};$$

agar $\mu = 0$ bo'lsa, $v = \sqrt{2gl\sin\alpha} = \sqrt{2gh}$.

7. Yuqoriga harakatlanish uchun kerak bo'lgan minimal kuch:

$$F = F_s + F_i = mg(\sin\alpha + \mu\cos\alpha).$$

8. Yukni h balandlikka ko'tarishda bajariladigan ish:

$$A = Fl = mgl(\sin\alpha + \mu\cos\alpha),$$

agar $\mu = 0$ bo'lsa, $A = mgl\sin\alpha = mgh$.

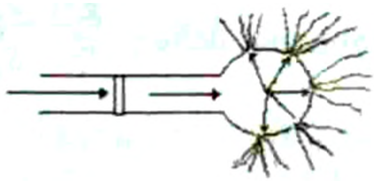
9. Qiya tekislikning FIK: $\eta = \frac{A_f}{A_s}\cdot 100\%$,

$$A_f = \Delta E_p = mgh = mgl\sin\alpha; \quad A_s = mgl(\sin\alpha + \mu\cos\alpha);$$

$$\eta = \frac{\sin\alpha}{\sin\alpha + \mu\cos\alpha}\cdot 100\% \quad \text{yoki} \quad \eta = \frac{1}{1+\mu\,\mathrm{ctg}\,\alpha}\cdot 100\%.$$

1.17. Suyuqlik va gazlar (gidrostatika)

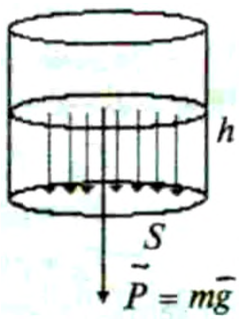
1. Paskal qonuni. Suyuqlik yoki gazga berilgan bosim barcha yo'nalishda bir xil va o'zgarishsiz uzatiladi: $\vec{p} = \text{const}$:



$$p = \frac{F}{S}; \text{ birligi } 1\ \text{Pa} = \frac{1\ \text{N}}{1\ \text{m}^2}.$$

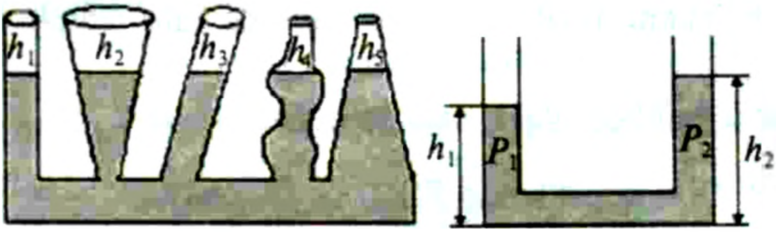
2. Suyuqlik ustunininig idish tubiga va devorlariga beradigan bosimi $p = \rho g h$, bu yerda ρ – suyuqlik zichligi, $g = 9{,}81$ m/s^2, h – suyuqlik ustunining balandligi.

Gidrostatik bosim suyuqlik zichligi, ustun balandligi h ga bog'liq bo'lib, yo'nalishiga bog'liq emas.



3. Tutash idishlar. Past qismlari o'zaro tutashgan idishlar sistemasiga tutash idishlar deyiladi. $h_1 = h_2 = h_3 = h_4 = h_5$, ya'ni suyuqlik ustuni balandliklari bir xil bo'ladi. Har xil zichlikli suyuqliklar bo'lganda

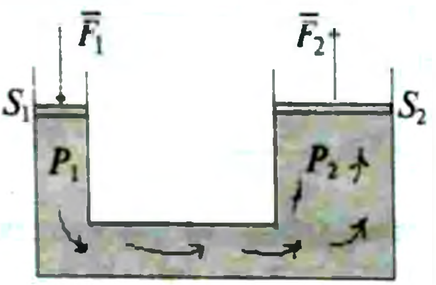
$$\rho_1 g h_1 = \rho_2 g h_2 \text{ va bundan } \frac{\rho_1}{\rho_2} = \frac{h_2}{h_1}.$$



4. Gidravlik press (mashina). Gidravlik press har xil diametrli ikkita tutash silindrik idishlardan iborat bo'lib, ularga suyuqlik to'ldirilib porshenlar o'rnatilgan:

$$p_1 = \frac{F_1}{S_1}, \quad p_2 = \frac{F_2}{S_2}, \quad p_1 \approx p_2.$$

Shuning uchun $\frac{F_2}{F_1} = \frac{S_2}{S_1}$ yuza necha marta katta bo'lsa, shuncha marta kuchdan yutiladi. Kichik porshenning siljishida bajarilgan ish gidravlik pressning bajarilgan ishiga teng, ya'ni



$$A_1 = A_2.$$

5. Arximed kuchi. Suyuqlik yoki gazga botirilgan jism o'zining hajmiga teng suyuqlik yoki gazni siqib chiqaradi va unga shu suyuqlik og'irligiga teng ko'taruvchi kuch ta'sir qiladi:

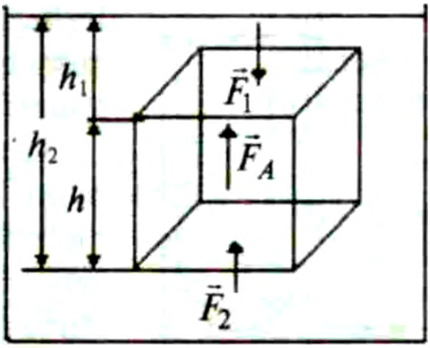
$$F_A = F_2 - F_1 = p_2 S - p_1 S = \rho g h_2 S - \rho g h_1 S,$$
$$F_A = \rho g (h_2 - h_1) \cdot S = \rho g h S = \rho g V,$$
$$F_A = \rho g V,$$

bu yerda ρ – suyuqlik zichligi, V – jism hajmi, $g = 9{,}8$ m/s^2.

Agar $\rho_j > \rho_s$ bo'lsa, jism cho'kadi,

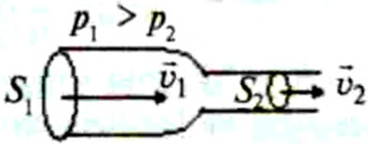
Agar $\rho_j < \rho_s$ bo'lsa, jism suzadi,

Agar $\rho_j = \rho_c$ bo'lsa, jism qalqib suzadi.



6. Statsionar oqim uchun uzluksizlik tenglamasi:

$\rho_1 S_1 \vec{v}_1 = \rho_2 S_2 \vec{v}_2$, $\rho = \text{const}$ bo'lsa,



$$S_1 v_1 = S_2 v_2, \quad \frac{v_1}{v_2} = \frac{S_2}{S_1}.$$

7. Bernulli tenglamasi:

$$p_1 + \rho g h_1 + \frac{\rho v_1^2}{2} = p_2 + \rho g h_2 + \frac{\rho v_2^2}{2} = \text{const},$$

bu yerda $\rho g h$ – gidrostatik, $\frac{\rho v^2}{2}$ – dinamik bosim. Oqim tezligi katta bo'lgan joylarda bosim kichik, tezligi kichik bo'lgan joylarda bosim katta bo'ladi.

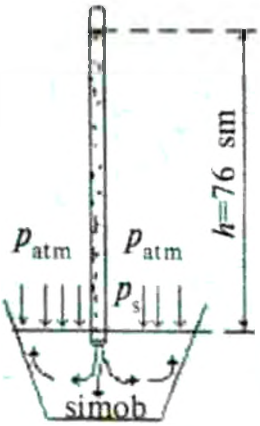
8. h – suyuqlik ustuni bo'lgan ochiq yuzali idish tubidan oqib chiqayotgan suyuqlik oqimi tezligi $v = \sqrt{2gh}$ (Torrichelli formulasi).

1.18. Atmosfera bosimi

Yer sharini o'rab olgan havo qobig'iga *atmosfera* deyiladi. Birlik yuzaga ta'sir qiluvchi kuchga **bosim** deyiladi:

$$p = \frac{F}{S}.$$

1. Torrichelli tajribasi – atmosfera bosilishini aniq-



lash. Atmosfera zarrachalarining yuza birligiga bergan og'irlik kuchi atmosfera bosimini beradi.

Uzunligi 1 m bo'lgan va bir tomoni kavsharlangan shisha nay simobga to'ldirilib, simobli idishga to'nkariladi. Naydan simob idishga oqib chiqa boshlaydi. Simob ustunining bosimi $p_s = \rho_s gh$, simobning to'kilishi to'xtagach, atmosfera bosimi p_s ga tenglashadi, ya'ni $p_{atm} = \rho_s gh$.

h = 760 mm simob ustuni normal atmosfera bosimi deyiladi va bir fizik atmosfera 1 atm deyiladi.

$$p_{atm} = 13,59 \cdot 10^3 \,{}^{kg}\!/_{m^3} \cdot 9,81 \,{}^{m}\!/_{s^2} \cdot 0,76 \text{ m} \approx$$

$$\approx 1,01 \cdot 10^5 \,{}^{N}\!/_{m^2} \approx 1 \cdot 10^5 \text{ Pa} = 100 \text{ kPa}.$$

2. Bosim birliklari:

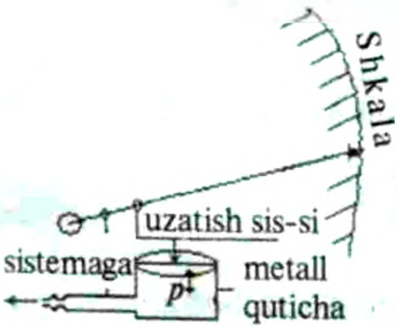
a) SI: $[P] = 1 \,{}^{N}\!/_{m^2} = 1$ Pa, $p_{atm} = 100$ kPa .

b) Texnikada: [p] = 1 mm sim. ust.

$[p]$ = 1 at (texnik atmosfera) = $\dfrac{1 \text{ kG}}{1 \text{ sm}^2} \approx 9,81 \cdot 10^4$ Pa .

$[p]$ = 1 atm (fizik atmosfera) = 760 mm sim. ust. = 10^5 Pa.

1 mm sim. ust. ≈ 133,3 Pa.

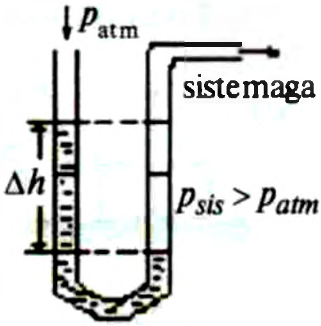


3. Atmosfera va gaz bosimini o'lchovchi asboblar:

1) barometr; 2) manometr.

Metalldan yasalgan barometr – barometr aneroidning tuzilishi quyidagicha (rasmga q.).

Manometr U-simon naydan iborat, ishchi jism – simob, spirt va boshqalar.



$$\Delta p = \rho g \Delta h, \quad p_{sis} = p_{atm} \pm \Delta p$$

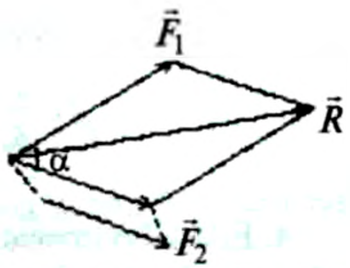
bu yerda ρ – suyuqlik zichligi; h – ustunlar farqi. U- simon manometr sistemadagi bosimning atmosfera bosimiga nisbatan farqini o'lchaydi.

1.19. Statika elementlari

Jism yoki jismlar sistemasining kuchlar ta'sirida muvozanat shart-sharoitini va muvozanat buzilganda uning harakat yo'nalishini va tezlanishini o'rganadigan fizika bo'limi – statikadir.

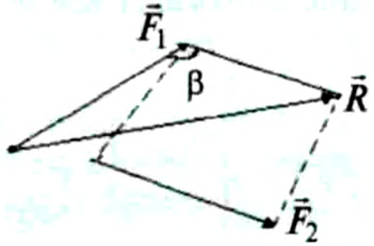
1. Kuchlarni qo'shish:

a) parallelogramm usuli:



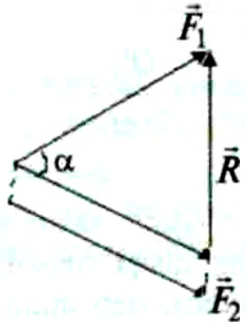
$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\alpha};$$

a) uchburchak usuli:



$$R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2\cos\beta}.$$

2. Kuchlarni ayirish:

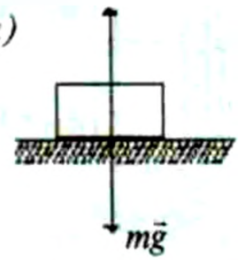


$$R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2\cos\alpha},$$

F_1 – kamayuvchi vektor, F_2 – ayriluvchi vektor; R – ayirma vektor.

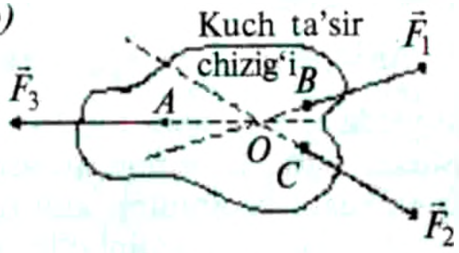
3. Erkin jismning muvozanat sharti:

a)



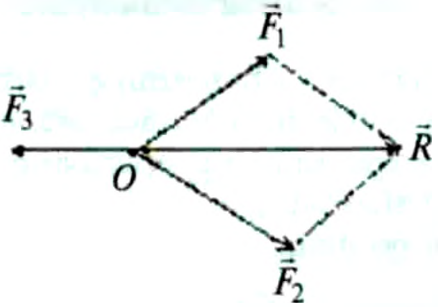
$m\vec{g} + \vec{N} = 0$

b)



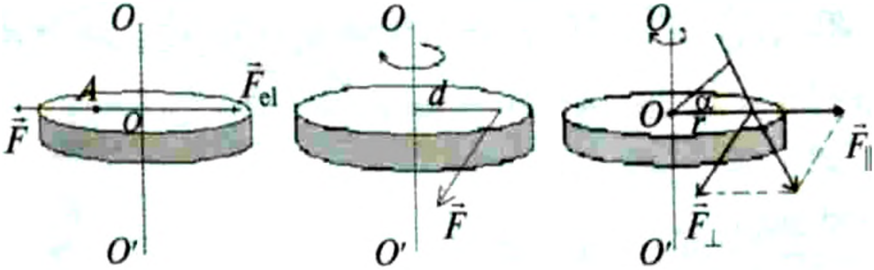
$\vec{R} + \vec{F}_3 = 0$

d)



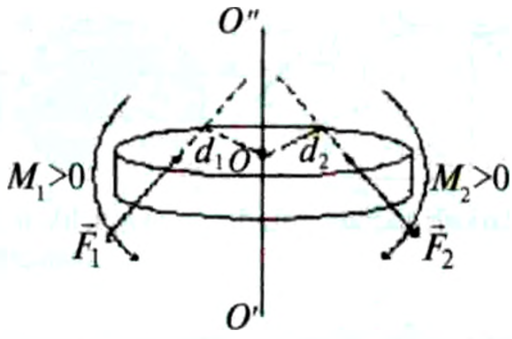
$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0; \quad \sum_i \vec{F}_i = 0$

4. Erkin bo'lmagan (bog'lanishga ega bo'lgan) jismning muvozanat sharti:



a) $M=0$ b) $M=Fd$ d) $M=F_\perp d$

Kuch ta'sir chizig'idan aylanish o'qigacha bo'lgan eng qisqa masofa (tushirilgan perpendikular) d – *kuch yelkasi* deb ataladi.



Ta'sir etuvchi kuchni kuch yelkasiga ko'paytmasi kuch momenti deb ataladi. Kuch momenti – kuchning aylantirish qobiliyatini tavsiflaydi:

$$\left.\begin{aligned} M_1 &= F_1 d_1 > 0 \\ M_2 &= F_2 d_2 < 0 \end{aligned}\right\}$$

Aylanish o'qiga ega bo'lgan jismning muvozanat sharti:

$$\vec{M}_1 + \vec{M}_2 = 0 \quad \text{yoki} \quad \sum_{i=1}^{n} \vec{M}_i = 0 .$$

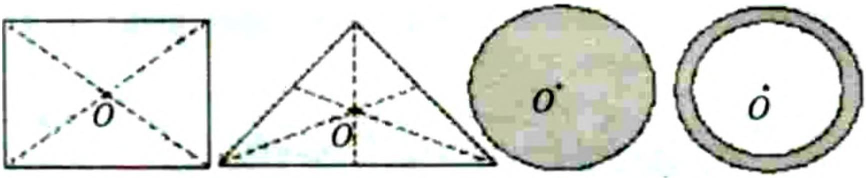
Jism yoki jismlar sistemasining umumiy muvozanat

sharti: $\sum_{i=1}^{n} \vec{F}_i = 0$ yoki $\sum_{i=1}^{n} \vec{M}_i = 0$, ya'ni, jismga ta'sir etuvchi kuchlarning vektor yig'indisi nolga teng bo'lsa yoki ta'sir etuvchi kuch momentlarining algebraik yig'indisi nolga teng bo'lsa, jism muvozanatda bo'ladi.

1.20. Statika

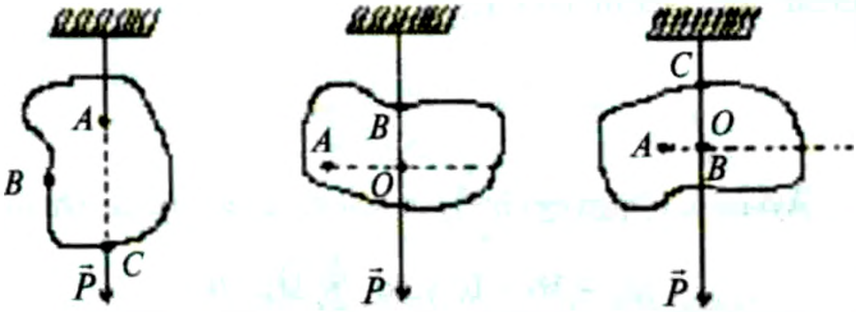
1. Jism yoki jismlar sistemasining og'irlik (massa) markazi – uning barcha qismlariga ta'sir etuvchi og'irlik kuchlarining teng ta'sir etuvchisi qo'yilgan nuqtada bo'ladi.

a) Bir jinsli aniq geometrik shaklga ega bo'lgan bir jinsli jismlarning og'irlik markazi uning geometrik markazida yotadi:



Og'irlik markazi jismda yotadi Og'irlik markazi jismdan tashqarida yotadi

b) Murakkab shaklga ega bo'lgan jismlarning og'irlik markazi og'irlik kuch chiziqlarining kesishgan nuqtasida yotadi:

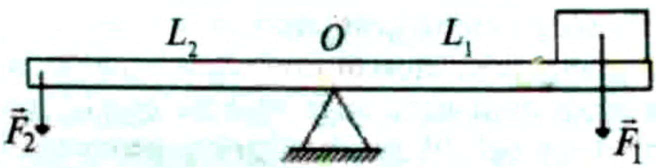


Jismning yoki jismlar sistemasining og'irlik (massa) markazidan o'tgan o'qqa nisbatan uning barcha qismlarining og'irlik kuchlarining momentlarini yig'indisi nolga teng, ya'ni $\sum P_i d_i = 0$.

2. Richag – bu qo'zg'almas o'q (yoki tayanch) atrofida aylanishi mumkin bo'lgan sterjen (yoki balka).

Muvozanat sharti:

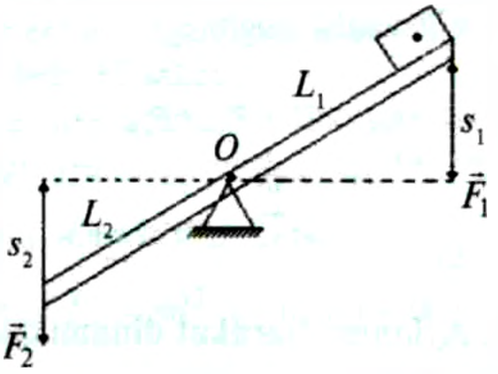
$$\vec{M}_1 + \vec{M}_2 = 0 \quad \text{yoki} \quad M_1 = M_2 \quad \text{va} \quad F_1 L_1 = F_2 L_2 \Rightarrow \frac{F_2}{F_1} = \frac{L_1}{L_2}$$



Kuchdan necha marta yutilsa, yo'ldan shuncha marta yutqaziladi va aksincha (mexanikaning oltin qoidasi)

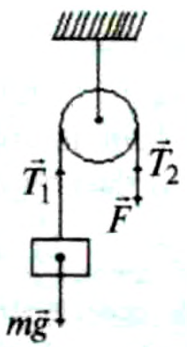
Bajarilgan ishlar:

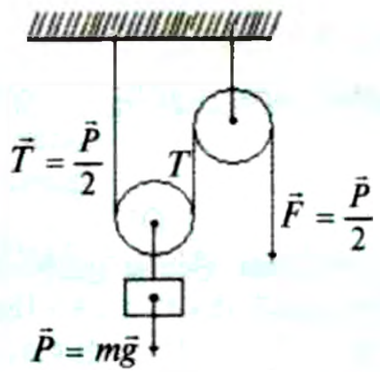
$$A_1 = F_1 s_1, \quad A_2 = F_2 s_2, \quad A_1 = A_2, \quad \frac{F_2}{F_1} = \frac{s_1}{s_2}.$$



3. Blok – bu disk shaklida bo'lib, uning gardishi bo'yicha arqon, tros, zanjir, tasma va boshqani o'tkazish mumkin bo'lgan oddiy mexanizmdir.

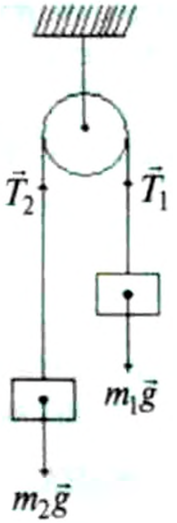
a) Ko'chmas blok b) Ko'char blok





Agar ishqalanish bo'lmasa, $F = mg$ va $T_1 = T_2 = T$.

Har bir ko'char blokda kuchdan ikki marta yutiladi, yo'ldan ikki marta yutqiziladi.



d) Ko‘chmas blokda jismlar sistemasining harakati ($m_1 > m_2$ bo‘lsin).

Sistemaning tezlanishi:

$$a = \frac{F_{\text{har}}}{m_{\text{um}}} = \frac{m_2 g - m_1 g}{m_1 + m_2} = \frac{m_2 - m_1}{m_1 + m_2} g \, .$$

Taranglik kuchi:

$$T_1 = T_2 \quad (F_{\text{ish}} \approx 0),$$

$$T_1 = m_1 g + m_1 a = m_1 (g + a),$$

$$T_2 = m_2 (g - a).$$

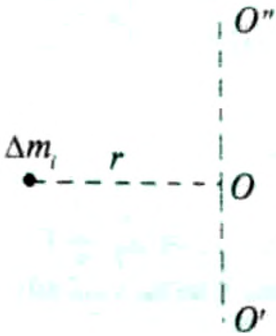
1.21. Aylanma harakat dinamikasi

Inersiya momenti. Jismning aylanish o‘qiga nisbatan *inersiya momenti* deb, jism har bir moddiy nuqtasi massasining aylanish o‘qigacha bo‘lgan masofa kvadratiga ko‘paytmalarining yig‘indisiga teng bo‘lgan fizik kattalikka aytiladi, ya’ni

$$I = \sum_{i=1}^{n} \Delta m_i r_i^2 \ ,$$

bunda Δm_i — jism i-nuqtasining massasi va r_i — undan aylanish o‘qigacha bo‘lgan masofa.

Inersiya momentining SI dagi birligi:



$$[I] = [m] \cdot [r^2] = 1 \text{ kg} \cdot 1 \text{ m}^2 = 1 \text{ kg} \cdot \text{m}^2$$

Jismning inersiya momentini hisoblash uchun uning $O'O''$ aylanish o‘qidan r masofadagi massasi Δm_i bo‘lgan jism nuqtasining inersiya momenti $I_i = \Delta m_i \cdot r_i^2$ ni aniqlaymiz (rasmga q.). Bu holda jismning $O'O''$ o'qqa nisbatan inersiya momenti

$$I = \sum_{i=1}^{n} \Delta m_i r_i^2 = mr^2$$

ga teng bo'ladi.

Jismning shakli va aylanish o'qining jism markaziga nisbatan qayerdan o'tganligiga qarab inersiya momentlari turlicha bo'ladi. Masalan:

a) massasi m va uzunligi l bo'lgan bir jinsli ingichka sterjen uchun: agar aylanish o'qi sterjenga tik ravishda uning massa markazidan o'tsa, $I = \frac{1}{12}ml^2$, uning bir uchidan o'tsa $I = \frac{1}{3}ml^2$ ga teng bo'ladi;

b) massasi m va radiusi R bo'lgan ingichka halqa, chambarak, yumaloq bir jinsli disk (silindr): massasi (m) gardish bo'ylab tekis taqsimlangan R radiusli g'ildirak uchun; agar aylanish o'qi asos tekisligiga tik ravishda markazdan o'tsa, $I = mR^2$, asos tekisligiga tik yo'nalishda disk markazidan o'tsa, $I = \frac{1}{2}mR^2$ ga teng;

d) massasi m va radiusi r bo'lgan bir jinsli shar yoki sfera uchun aylanish o'qi uning markazidan o'tsa, $I = \frac{2}{5}mR^2$ ga teng.

Aylanma harakat dinamikasining asosiy tenglamasi. To'g'ri chiziqli harakat dinamikasining asosiy tenglamasi $F = ma$ edi. Aylanma harakat uchun esa:

$$M = r \cdot F,\ M = r \cdot m \cdot a,\ a = r \cdot \varepsilon,\ M = r^2 \cdot m \cdot \varepsilon$$

va bundan $M = I\varepsilon$ kelib chiqadi.

Inersiya momenti o'zgarmas bo'lgani uchun aylanma harakat dinamikasining asosiy tenglamasi quyidagi ko‘rinishni oladi:

$$M = I\varepsilon .$$

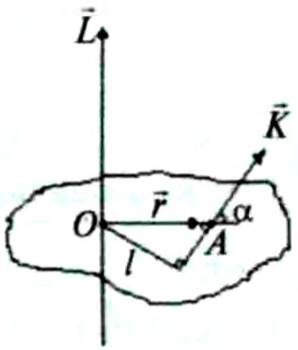
Demak, jismga ta’sir etuvchi kuch momenti uning inersiya momenti bilan burchak tezlanishining ko‘paytmasiga teng.

Impuls momenti. Moddiy nuqtaning biror o‘qqa nisbatan *impuls (harakat miqdori) momenti* deb, uning impulsi bilan aylanish o‘qigacha bo‘lgan masofani vektor ko‘paytmasiga teng bo‘lgan fizik kattalikka aytiladi:

$$\vec{L} = \left[\vec{r} \cdot \vec{K}\right] = \left[\vec{r} \cdot m\vec{v}\right].$$

Uning moduli:

$$L = r \cdot K \cdot \sin\alpha = mvr \cdot \sin\alpha = K \cdot l ,$$



bu yerda $\vec{r}$ — aylanish o‘qidan A nuqtagacha bo‘lgan radius-vektor; $r\sin\alpha = l$, l — O nuqtaga nisbatan kuch yelkasi; α – $\vec{r}$ va $\vec{K}$ vektorlar orasidagi burchak (rasmga q.).

SI dagi birligi 1 $\text{kg} \cdot \frac{\text{m}^2}{\text{s}}$.

Impuls momenti va aylanma harakat dinamikasi xarakteristikalari orasidagi bog‘lanish. Aylanma harakat qilayotgan jism uchun impuls momenti;

$$L = I \cdot \omega$$

ga teng.

Shuningdek, ilgarilanma harakat dinamikasining asosiy qonunining $\frac{d\vec{K}}{dt} = \vec{F}$ ifodasiga o‘xshash qattiq jism aylanma harakat dinamikasining asosiy qonunini yozamiz: $\frac{d\vec{L}}{dt} = \vec{M}$ (yoki $\frac{\Delta\vec{L}}{\Delta t} = \vec{M}$).

Impuls momentining saqlanish qonuni. Agar sistema yopiq bo'lsa, unda tashqi ta'sir etuvchi kuchlar momenti nolga teng bo'ladi, ya'ni $\vec{M} = 0$. Bu holda $\frac{d\vec{L}}{dt} = 0$.

Agar o'zgarmas kattalikning hosilasigina nolga teng bo'lishini hisobga olsak, $\vec{L} = \text{const}$.

Bu ifoda impuls momentining saqlanish qonuni deyiladi. Demak, yopiq sistemada impuls momenti vaqt o'tishi bilan o'zgarmaydi.

Aylanma harakat qilayotgan jismning kinetik energiyasi. Aylanma harakat qilayotgan jismning kinetik energiyasini $\Delta W_{ki} = \frac{\Delta m_i v_i^2}{2}$ va $\Delta W_k = \sum \frac{\Delta m_i v_i^2}{2}$ ifodalar yordamida topamiz. Har bir nuqtasi uchun $v_i = r_i \cdot \omega$ bo'lganidan

$\Delta W_k = \sum \frac{\Delta m_i \cdot r_i^2 \cdot \omega^2}{2} = \frac{I \cdot \omega^2}{2}$, chunki $\sum \Delta m_i \cdot r_i^2 = I$ edi.

Demak, $W_k = \frac{I\omega^2}{2}$.

Agar jism ham ilgarilanma, ham aylanma harakatda bo'lsa, uning to'la kinetik energiyasi ilgarilanma va aylanma harakat kinetik energiyalarining yig'indisiga teng bo'ladi:

$$W_k = \frac{mv_c^2}{2} + \frac{I_c\omega^2}{2},$$

Bu yerda v_c – jism massa markazining tezligi; I_c – jismning massa markaziga nisbatan inersiya momenti.

Ilgarilanma va aylanma harakat dinamikasi xarakteristikalari

Ilgarilanma harakat	Aylanma harakat
Ko'chish va yo'l: $\vec{r}$ va s	Burilish burchagi, φ
Tezlik $\vec{v} = \frac{\Delta\vec{r}}{\Delta t}$ yoki $\vec{v} = \frac{d\vec{r}}{dt}$, $v = \frac{ds}{dt}$	Burchak tezlik $\omega = \frac{\Delta\varphi}{\Delta t}$ yoki $\omega = \frac{d\varphi}{dt}$
Tezlanish $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$ yoki $\vec{a} = \frac{d\vec{v}}{dt}$	Burchak tezlanish $\varepsilon = \frac{\Delta\omega}{\Delta t}$ yoki $\varepsilon = \frac{d\omega}{dt}$
Massa m	Inersiya momenti $I = mr^2$
Kuch $\vec{F}$	Kuch momenti $M = lF\sin\alpha$ yoki $\vec{M} = [\vec{l} \cdot \vec{F}]$
Impuls $\vec{K} = m\vec{v}$	Impuls momenti $L = I\omega$ yoki $\vec{L} = I \cdot \vec{\omega}$
Dinamikaning asosiy qonuni	
$\frac{\Delta\vec{K}}{\Delta t} = \vec{F}$ yoki $\frac{d\vec{K}}{dt} = \vec{F}$	$\frac{\Delta\vec{L}}{\Delta t} = \vec{M}$ yoki $\frac{d\vec{L}}{dt} = \vec{M}$
Ish $\Delta A = F \cdot \Delta S \cdot \cos\alpha$ yoki $dA = (\vec{F} \cdot d\vec{S})$	Ish $\Delta A = F \cdot \Delta S \cdot \cos\alpha$ yoki $dA = M \cdot d\varphi$
Kinetik energiya $\frac{m \cdot v^2}{2}$	Kinetik energiya $\frac{I \cdot \omega^2}{2}$

2.1. Molekular-kinetik nazariya

Moddalarning xossa va xususiyatlari ularni tashkil qilgan atom yoki molekulalarning harakati va o'zaro ta'siri asosida tushuntirib beruvchi nazariyaga *molekular-kinetik nazariya* deyiladi.

1. Molekular-kinetik nazariya asoslari:

a) barcha moddalar atom yoki molekulalardan tashkil topgan;

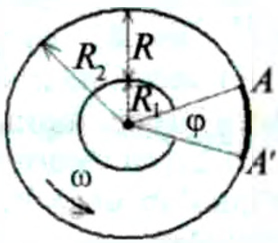
b) atom yoki molekulalari to'xtovsiz xaotik harakat qiladi;

d) ular orasida o'zaro tortishish va itarish kuchlari mavjud.

Tajribadagi isbotlari: moddaning uch holati (gaz, suyuq, qattiq), diffuziya hodisasi, Broun harakati va hokazo.

2. Gaz molekulasining tezligini o'lchash (Shtern tajribasi): $v = \frac{l}{\Delta t} = \frac{(R_2 - R_1)\cdot\omega\cdot R_2}{S}$. $l = R_2 - R_1$, $S = \overset{\cup}{AA'} = Y \cdot R_2$

Ko'pincha $R_2 \gg R_1$, $v = \frac{\omega\cdot R_2^2}{S}$.



Xulosa: a) tajriba natijalarida aniqlangan tezlik qiymatlari nazariya bo'yicha hisoblangan tezlik qiymatlariga juda yaqin ekan.

b) o'rtacha qiymatdan katta va kichik tezlikli molekulalar (atomlar) mavjud ekan.

3. Molekulalarning tavsiflari:

1 mol moddadagi molekulalar soni (etalon) – 12 g ^{12}C ugleroddagi atomlar soni – Avogadro soni $N_A = 6{,}022\cdot10^{23}$ mol^{-1} ga teng. Modda miqdori (mollar soni) $\nu = \frac{N}{N_A}$, N – molekulalar soni. Molar massa $\mu = \frac{M}{\nu}$.

Bitta molekulaning massasi: $m=\frac{\mu}{N_A}$ yoki $m=\frac{M}{N}$.

Ixtiyoriy moddadagi molekulalar soni $N=\nu N_A=\frac{M}{\mu}N_A$.

Molekulalarning o'lchami $\sim 10^{-8}$ sm yoki $\sim 10^{-10}$ m tartibida, massasi $\sim 10^{-24}-10^{-22}$ g yoki $10^{-27}-10^{-25}$ kg.

Gaz molekulalarining tezliklari $\sim 10^2 \div 10^3$ m/s. Masalan, $T=300$K da $\upsilon_{havo}\approx 500$m/s.

4. Broun harakati.

Suyuqlik yoki gazlardagi muallaq zarrachalarning to'xtovsiz tartibsiz (xaotik) harakatiga **Broun harakati** deyiladi.

Qonuniyatlari:

a) zarrachalarning harakati gaz va suyuqliklarning biologik xossalariga bog'liq emas;

b) zarrachalarning tezligi temperaturaga to'g'ri proporsionaldir;

d) zarrachalarning tezligi zarra massasi va o'lchamiga teskari proporsionaldir;

e) zarrachalarning harakat trayektoriyasi siniq to'g'ri chiziqlardan iborat;

f) zarrachalarning xaotik harakatiga molekulalarning to'qnashib unga bergan impulslarining o'zaro kompensatsiyalanmaganligidadir.

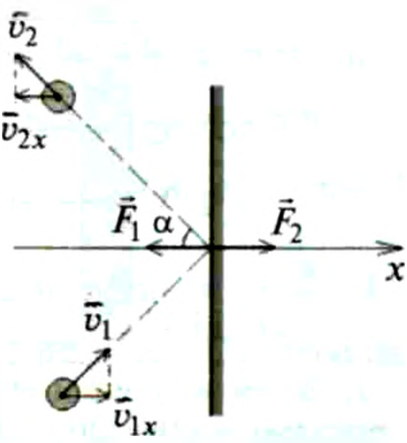
2.2. Molekular-kinetik nazariyaning asosiy tenglamasi

1. Molekula impulsining o'zgarishi:

$$K_{2x}-K_{1x}=m\upsilon_{1x}-m\upsilon_{2x}=m\upsilon_x-(-m\upsilon_x)=$$
$$=2m\upsilon_x=F_1\cdot\Delta t,$$

$F_1\cdot\Delta t$ — kuch impulsi.

2. Gaz bosimi:



$$p = \frac{F}{S} = \frac{F_{um} \cdot \Delta t}{S \cdot \Delta t} =$$

$$= \frac{N_x \cdot \bar{F}_1 \cdot \Delta t}{S \cdot \Delta t} = \frac{N_x \cdot 2mV_x \cdot \Delta t}{S \cdot \Delta t},$$

bu yerda N_x – x yo'nalishda s devorga urilgan molekulalar soni. Gaz bosimi molekulalarning idish devorlari bilan to'qnashib ularga impuls berish natijasida vujudga keladi.

3. Paskal qonuniga asosan: $p_x = p_y = p_z = p$.

4. Molekular-kinetik nazariyaning asosiy tenglamasi:

$$p = \frac{1}{3} nm\bar{v}^2 = \frac{2}{3} n \cdot \frac{m\bar{v}^2}{2} = \frac{2}{3} n\bar{E}_k$$ yoki $m \cdot n = \rho$

bo'lgani uchun $p = \frac{1}{3}\rho\bar{v}^2$; bu yerda $\bar{E}_k = \frac{m\bar{v}^2}{2}$ – molekulaning o'rtacha kinetik energiyasi, $n = \frac{N}{V}$ – gaz molekulalarining konsentratsiyasi.

Gaz bosimi hajm birligidagi barcha molekulalarning kinetik energiyasining 2/3 qismiga teng.

5. Temperatura shkalasi.

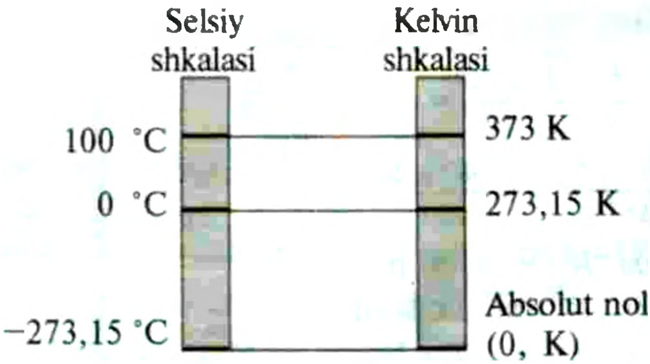
$$T = t^\circ + 273{,}15 \approx t^\circ + 273,$$

t° – Selsiy shkalasidan temperatura (harorat).

6. Temperatura – molekulalarning o'rtacha kinetik energiyasining o'lchovi

$$\bar{E}_k = \frac{3}{2} kT$$

bu yerda $k = 1{,}38 \cdot 10^{-23}$ J/K – Bolsman doimiysi.
Demak, $T = OK$ da molekulalar harakatlanishdan to'xtaydi.



7. Bosim p, konsentratsiya n va absolut temperatura T orasidagi bog'lanish:

$$p = nkT.$$

8. Molekulalarning tezliklari:

a) o'rtacha kvadratik tezlik $\overline{E}_k = \frac{mv^2}{2} = \frac{2}{3}kT$, bundan

$$v_{kv} = \sqrt{\frac{3kT}{m}} \text{ yoki } v_{kv} = \sqrt{\frac{3RT}{\mu}}; \left(\overline{v}_{kv}^2 = \frac{v_1^2 + v_2^2 + v_3^2 + \ldots + v_n^2}{N} \right);$$

b) o'rtacha arifmetik tezlik: $\overline{v} = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi\mu}}$.

$$\left(\overline{v} = \frac{v_1 + v_2 + v_3 + \ldots + v_n}{N} \right)$$

Temperatura: 1) moddaning issiqlanganlik darajasini; 2) issiqlik almashinishi yo'nalishini; 3) issiqlik muvozanatini xarakterlaydi.

2.3. Ideal gaz holat tenglamasi.
Mendeleyev – Klapeyron tenglamasi

Gaz yoki gazlar sistemasini xarakterlaydigan parametrlari: p, V va T orasidagi bog'lanishni ifodalaydigan tenglamaga gaz holat tenglamasi deb ataladi.

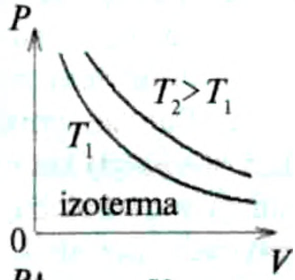
1. Gaz bosimi: $p = nkT$.
2. Gaz molekulalarining konsentratsiyasi:

$$n = \frac{N}{V} = \frac{\nu N_A}{V} = \frac{M}{\mu} \cdot \frac{N_A}{V}$$

bu yerda: $\nu = \dfrac{M}{\mu}$ – mollar soni, M – gaz massasi, μ – gazning molyar massasi, V – gaz egallagan hajm.

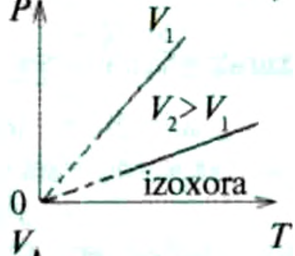
3. $p = nkT = \dfrac{M}{\mu} \cdot \dfrac{N_A \cdot k \cdot T}{V}$; $k \cdot N_A = R = 8{,}31$ J/mol·K – universal gaz doimiysi boʻlgani uchun $pV = \dfrac{M}{\mu} RT$ – ideal gaz holat tenglamasi – Mendeleyev–Klapeyron tenglamasi. $\nu = \dfrac{M}{\mu} = 1$ mol boʻlsa, $pV = RT \Rightarrow \dfrac{pV}{T} = \text{const}$ – 1 mol gaz uchun holat tenglamasi – Klapeyron tenglamasidir.

Normal sharoitda: p_0 = 100 kPa, T_0 = 273 K, $V_{0\mu}$ = $= 22{,}4 \cdot 10^{-3}$ m^3/mol uchun $\dfrac{p_0 V_0}{T_0} = R$ – 1 mol gazni 1 K ga isitilganda gazning bajargan ishiga son jihatidan teng.

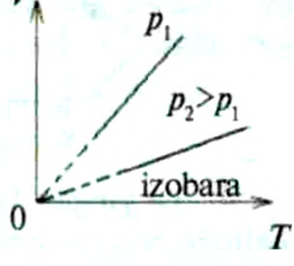


4. Gazlardagi izojarayonlar:

a) izotermik jarayon (T = const) pV = const – Boyl–Mariott qonuni, ya'ni $p \sim \dfrac{1}{V}$;



b) izoxorik jarayon (V = const) $p = C \cdot T = p_0 \alpha T$ – Sharl qonuni, ya'ni $p \sim T$. Bu yerda C = const, p_0 – 0 °C dagi gaz bosimi, α – bosimning temperaturaviy koeffitsiyenti;



d) izobarik jarayon (p = const) $V = CT = V_0 \beta T$ – Gey-Lyussak qonuni, ya'ni $V \sim T$. Bu yerda $C =$ const, V_0 0 OC dagi gaz hajmi, β — hajmning temperatura koeffitsiyenti.

5. Dalton qonuni: o'zaro reaksiyaga kirishmaydigan gaz aralashmasining umumiy bosimi

$$p = p_1 + p_2 + p_3 + \ldots + p_n,$$

bu yerda p_i — parsial bosimlar.

2.4. Bug'lanish va kondensatsiya

1. **Bug'lanish** — moddaning suyuq holatidan gaz holatiga o'tish jarayonidir. Kondensatsiya esa moddaning bug' (gaz) holatidan suyuq holatiga o'tish jarayonidir.

Bug'lanish:

a) modda tabiatiga (molekulalar orasidagi kuchga),

b) temperaturaga,

d) ochiq sirt yuzasiga,

e) tashqi bosimga,

f) atmosfera harakati (shamol)ga bog'liq.

2. Bug'lanayotgan molekula ichki (suyuqlik molekulalari orasidagi) kuchlarga qarshi A_i va tashqi (suyuqlik yuzasidagi molekulalar orasidagi) kuchlarga qarshi A_t ishlarni bajaradi. Bu ish kattaligi solishtirma bug'lanish ishi bilan xarakterlanadi, ya'ni $r = \frac{Q}{m}$ va $Q = r \cdot m$; bu yerda r — 1 kg suyuqlikni to'la bug'lantirish uchun zarur bo'lgan issiqlik miqdoriga solishtirma bug'lanish issiqligi deyiladi.

3. Bug' $\nearrow$ to'yingan bug' — o'zining suyuqligi bilan dinamik muvozanatda bo'lgan bug', ya'ni 1 s da $N_{s\to b} = N_{b\to s}$.

Bug' $\searrow$ to'yinmagan bug' — dinamik muvozanatda bo'lmagan bug', ya'ni $N_{s\to b} \neq N_{b\to s}$.

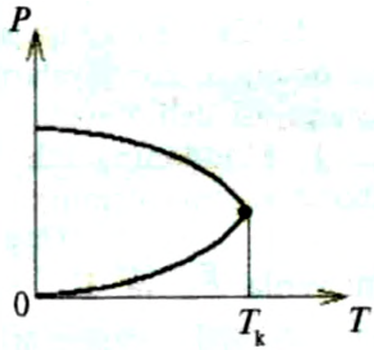
4. To'yingan bug' bosimi $p \sim T$ va $p = nkT$, lekin u hajmga bog'liq emas.

5. Qaynash – suyuqlikning butun hajmi bo'yicha pufakchalarning hosil bo'lib, intensiv ravishda suyuqlik yuziga harakat qilib yorilish jarayonidir.

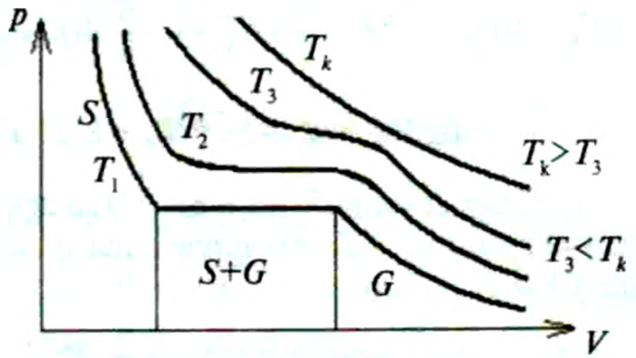
T a ' r i f i . Qaynash – suyuqlikni butun hajmi bo'yicha bug'lanish jarayonidir.

Qaynash sharti: pufakcha ichidagi bug' va gaz bosimi $P_b + P_{gaz} \geq P_{tashqi}$.

6. Kritik temperatura T_k da moddaning suyuqlik va bug' holatlarining chegarasi yo'qolib, modda bir jinsli bo'lib qoladi. $T > T_k$ da modda har qanday bosimda suyuqlikka aylanmaydi.



7. Real gaz (bug') izotermalari. Kichik bosim p larda gaz (bug'); katta p larda gaz + suyuqlik va yuqori p larda suyuq holatlarda bo'ladi.



8. 1 m^3 havodagi suv bug'ining miqdori (ρ) yoki parsial bosimi p absolut namlik deyiladi.

Berilgan temperaturada suv bug'ining zichligi (ρ) (yoki bosimi p)ning shu temperaturadagi to'yingan bug' zichligi ρ_0 (yoki bosimi p_0)ga nisbatan havoning nisbiy namligi deyiladi:

$$\varphi = \frac{\rho}{\rho_0} \cdot 100\%, \qquad \varphi = \frac{p}{p_0} \cdot 100\%.$$

9. Havodagi suv bug'ining to'yingan bug'ga aylanuvchi temperatura t_{sh} shudring nuqtasi deyiladi. $t \leq t_{sh}$ da shudring tushadi va tuman paydo bo'ladi. Namlik gigrometr va psixrometr yordamida o'lchanadi.

2.5. Termodinamika

Moddani tashkil qilgan barcha zarrachalarining kinetik va potensial energiyalarining yig'indisi moddaning ichki energiyasi deb ataladi.

1. Moddaning ichki energiyasi (N – zarrachadan iborat sistema uchun):

$$U = N\bar{E}_k + N\bar{E}_p,$$

bu yerda $\bar{E}_k$ va $\bar{E}_p$ – zarrachalarning o'rtacha kinetik va potensial energiyalari.

2. Ideal gazning ichki energiyasi.

Ideal gazda $E_p = 0$, chunki f_{tort} va $f_{itar} \approx 0$.

$$U = N\bar{E}_k = \nu N_A \cdot \frac{3}{2}kT = \frac{3}{2}\nu RT = \frac{3}{2}\frac{M}{\mu}RT = \frac{3}{2}pV,$$

bu yerda $\nu = \dfrac{M}{\mu}$ – mollar soni, $R = kN_A = 8{,}31$ J/mol·K.

3. Termodinamikaning I qonuni: sistemaga berilgan issiqlik miqdori uning ichki energiyasining o'zgarishi ΔU bilan uning bajargan ishi A ning yig'indisiga teng:

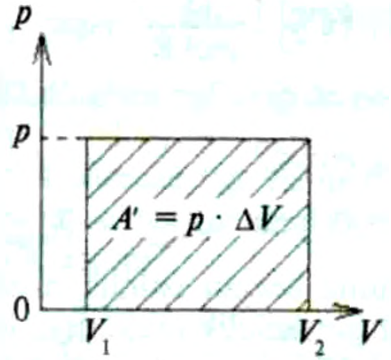
$$Q = \Delta U + A \text{ (yoki } \Delta U = Q + A'),$$

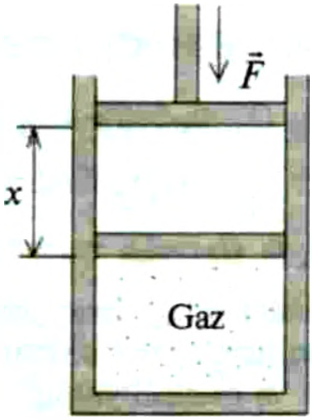
bu yerda Q – sistemaga berilgan issiqlik miqdori, ΔU – ichki energiyasi o'zgarishi; A' – tashqi kuchning ishi ($A = -A'$).

Termodinamikaning I qonuni issiqlik jarayonlari uchun energiyaning saqlanish qonunini ifodalaydi.

a) Gaz hajmi o'zgarganda bajarilgan ish:

$$A = F \cdot x = p \cdot S \cdot x = p \cdot \Delta V = p \cdot (V_2 - V_1).$$





4. Izojarayonlar: a) izotermik jarayon $Q = A$, chunki $T=$ const va $\Delta U = 0$, $A = \dfrac{M}{\mu} RT \cdot \ln \dfrac{V_2}{V_1}$;

b) izoxorik jarayon $Q = \Delta U$, chunki $V=$ const va $A = 0$.

d) izobarik jarayon $Q = \Delta U + A$, $p =$ const va $A = p \cdot \Delta V$;

e) adiabatik jarayonda $Q = 0$, $A = -\Delta U$.

Bu holda bajarilgan ish sistemaning ichki energiyasining kamayishiga teng.

2.6. Issiqlik miqdori

Bir jismdan ikkinchi jismga ish bajarmasdan energiyaning uzatilishiga issiqlik uzatilishi yoki issiqliq almashinishi deyiladi. Issiqlik almashinishi natijasida uzatilgan energiya issiqlik miqdori deyiladi.

1. Issiqlik miqdori.

m massali jismni Δt ga isitish uchun kerak bo'lgan issiqlik miqdori

$$Q = cm(t_2 - t_1) = cm\Delta t ,$$

bu yerda: $c = \dfrac{C}{m}$ — solishtirma issiqlik sig'imi, birligi J/kg · K; C — jismning issiqlik sig'imi, birligi J/K. Molyar issiqlik sig'imi $C_\mu = c \cdot \mu = \frac{C}{\nu}$; $[C_\mu] = \frac{J}{mol \cdot K}$. Agar $t_2 > t_1$ bo'lsa $Q > 0$, isitilish; $t_2 < t_1$ bo'lsa, $Q < 0$ – sovish bo'ladi.

2. Issiqlikning balans tenglamasi:

$$Q_1 + Q_2 + Q_3 + ... + Q_n = 0 \text{ yoki } Q_{olgan} = Q_{bergan}.$$

Sistemadagi issiq jismlarning bergan issiqlik miqdori sovuq jismlar tomonidan olingan issiqlik miqdoriga teng.

3. m massali yoqilg'i yonganda ajralib chiqqan issiqlik miqdori

$$Q = q \cdot m,$$

bu yerda q – yoqilg'ining solishtirma yonish issiqligi, birligi $[q]$ = J/kg.

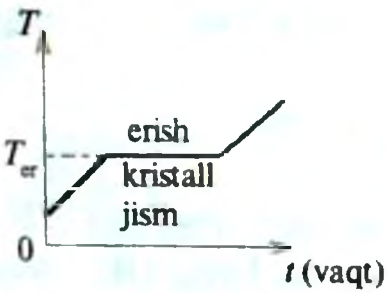
4. m massali suyuqlikni to'la bug'ga aylantirish uchun kerak bo'lgan issiqlik miqdori (T = const)

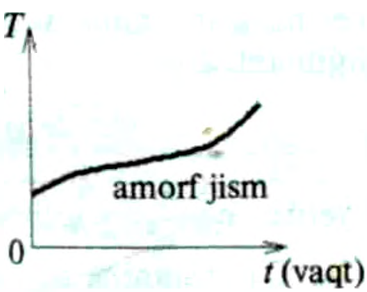
$$Q = r \cdot m,$$

bu yerda r – solishtirma bug'lanish issiqligi, birligi J/kg yoki m massali bug' suyuqlikka aylanganda ajralib chiqqan issiqlik miqdori $Q = -\lambda \cdot m$ ga teng.

5. m massali jismni eritish uchun zarur bo'lgan issiqlik miqdori $Q = \lambda \cdot m$, bu yerda λ – solishtirma erish issiqligi, birligi J/kg va suyuqlik qattiq jismga aylanganda $Q = -\lambda \cdot m$ issiqlik miqdori ajralib chiqadi.

Amorf jismlar aniq erish temperaturasiga ega emas.





2.7. Ideal gazning issiqlik sig'imi

Ideal gazning issiqlik sig'imi molekulalarning harakatini xarakterlaydigan mustaqil koordinatalar soni – erkinlik darajasi i ga hamda hajmga va bosimga bog'liq.

Hajm o'zgarmaganda (V = const) gazning molyar issiqlik sig'imi:

$$C_V = \frac{(\Delta Q)_V}{\nu \cdot \Delta T} = \frac{\Delta U + p \cdot \Delta V}{\nu \cdot \Delta T} = \frac{\frac{i}{2}\nu R \Delta T}{\nu \cdot \Delta T} = \frac{i}{2} R ,$$

bu yerda $\nu = \frac{M}{\mu}$ – molyar soni, i – erkinlik darajasi va $\Delta V = 0$.

Bosim o'zgarmas (p = const) bo'lganda gazning molyar issiqlik sig'imi:

$$C_p = \frac{(\Delta Q)_p}{\nu \cdot \Delta T} = \frac{\Delta U + p \cdot \Delta V}{\nu \cdot \Delta T} = \frac{\frac{i}{2}\nu R \Delta T + \nu R \Delta T}{\nu \cdot \Delta T} = \frac{i}{2} R + R .$$

C_p va C_V orasidagi bog'lanish (Mayer formulasi):

$$C_p - C_V = R,$$

R – universal gaz doimiysi bo'lib, 1 mol gaz 1 K ga qizdirilganda uning bajargan ishiga teng bo'lib, $R = 8,31 \frac{\text{J}}{\text{mol} \cdot \text{K}}$ ga teng. C_p ning C_V ga nisbati $\gamma = \frac{C_p}{C_V}$ – adiabata ko'rsatkichi deyiladi. Molekulalari:

1 atomli gazlar uchun $i = 3$, $C_V = \frac{3}{2} R$, $C_p = \frac{5}{2} R$, $\gamma \approx 1,67$.

2 atomli gazlar uchun $i = 5$, $C_V = \frac{5}{2} R$, $C_p = \frac{7}{2} R$, $\gamma \approx 1,40$.

3 va ko'p atomli gazlar uchun $i = 6$, $C_V = 3R$, $C_p = 4R$, $\gamma \approx 1,33$.

Solishtirma issiqlik sig'imi:

$$c_V = \frac{C_V}{\mu} = \frac{i}{2}\cdot\frac{R}{\mu} \quad \text{va} \quad c_p = \frac{C_p}{\mu} = \left(\frac{i}{2}+1\right)\cdot\frac{R}{\mu}.$$

2.8. Qattiq jism xossalari

Qattiq jismlar aniq hajm va shaklga ega: kristall jismlar, amorf jismlar shaklida bo'ladi.

1. Kristall jismlar – atomlari, molekulalari yoki ionlari fazoda ma'lum tartibda joylashgan qattiq jismlardir. Fazodagi zarrachalarni birlashtirishda hosil qilgan panjara kristall panjara deyiladi. Kichik kristallardan tashkil topgan qattiq jism *polikristall* deyiladi.

Kristallar: a) erish temperaturasiga; b) aniq kristall panjaraga ega; d) fizik parametrlari yo'nalishga bog'liq. Amorf jismlar – zarrachalari tartibsiz joylashgan. Xossalari: a) erish temperaturasiga ega emas; b) fizik xossalari yo'nalishga bog'liq emas – izotropdir.

2. Qattiq jismning issiqlikdan chiziqli kengayishi

$$l = l_0(1 + \alpha \cdot \Delta t^\circ),$$

bu yerda l – berilgan t temperaturadagi va l_0 – t_0 dagi uzunliklari, $\Delta t^\circ = t^\circ - t_0^\circ$ va $\alpha = \frac{l - l_0}{l_0 \cdot \Delta t^\circ} = \frac{\Delta l}{l_0 \cdot \Delta t^\circ}$ chiziqli kengayishning temperatura koeffitsiyenti, birligi K^{-1} (yoki $^\circ C^{-1}$). α – har xil jismlar uchun har xil, ular tajribada aniqlanadi.

3. Jismning (yoki moddaning) issiqlikdan hajmiy kengayishi:

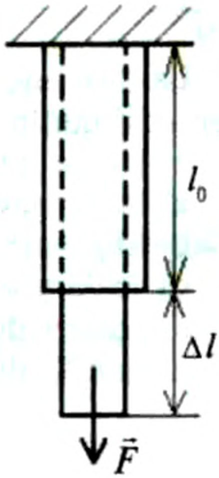
$$V = V_0(1 + \beta \cdot \Delta t^\circ),$$

bu yerda: V – berilgan t temperaturadagi, V_0 esa t_0 temperaturadagi jismning (moddaning) hajmlari; $\Delta t^\circ = t^\circ - t_0^\circ$

va $\beta = \frac{V - V_0}{V_0 \cdot \Delta t^\circ} = \frac{\Delta V}{V_0 \cdot \Delta t^\circ}$; β — hajmiy kengayishning temperaturaviy koeffitsiyenti, birligi K^{-1} (yoki $^\circ C^{-1}$).

4. Hajmiy kengayish koeffitsiyenti bilan chiziqli kengayish koeffisiyenti orasidagi bog'lanish $\beta \approx 3\alpha$.

5. Qattiq jismning cho'zilish (yoki siqilish) elastik deformatsiyasi uchun Guk qonuni (1676-y.):



$$\frac{|\Delta l|}{l_0} = \frac{1}{E} \cdot \frac{F}{S} \quad \text{yoki} \quad \sigma = E \cdot |\varepsilon|,$$

bu yerda: $\Delta l = l - l_0$ — absolut deformatsiya; $\varepsilon = \frac{\Delta l}{l_0}$ — nisbiy deformatsiya;

E — Yung moduli, $\sigma = \frac{F}{S}$ — kuchlanish, birligi $\text{Pa} = \frac{\text{N}}{\text{m}^2}$; F — ta'sir etuvchi kuch;

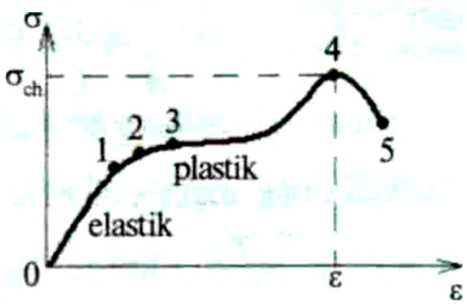
S — sterjenning ko'ndalang kesim yuzasi.

E — modda tabiatiga, tarkibiga va temperaturaga bog'liq:

Grafikda: 0—1 soha uchun Guk qonuni o'rinli;

1—2 soha elastik deformatsiya sohasi, Guk qonuni o'rinli emas;

2—3 soha noelastik deformatsiyaning boshlanishi;



3—4 soha noelastik deformatsiya sohasi;

4 — mustahkamlik chegarasi;

4—5 soha jismning yemirilish sohasi.

Mustahkamlik zapasi: $n = \frac{\sigma_{ch}}{\sigma_{yuk}}$.

2.9. Issiqlik dvigatellari

Issiqlik energiyasini mexanik energiyaga aylantirib beruvchi qurilmaga **issiqlik dvigatellari** deyiladi.

1. Uning turlari:

a) bug' mashinasi;

b) bug' turbinasi;

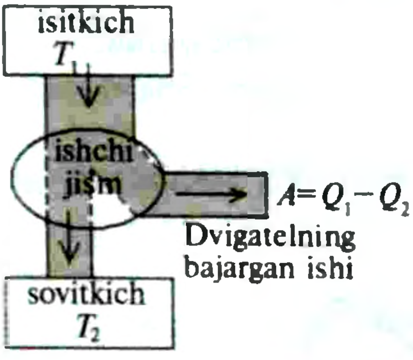
d) ichki yonish dvigateli;

e) reaktiv dvigatel.

2. Issiqlik dvigatelining F.I.K:

$$\eta = \frac{A}{Q} \cdot 100\%,$$

bu yerda A — bajarilgan foydali ish. Q — yonilg'i yonganda ajralib chiqqan issiqlik miqdori. Dvigatellarda issiqlik yo'qotiladi hamda ishqalanish kuchlariga qarshi energiyalar sarf bo'ladi.



3. Issiqlik mashinasining prinsipial sxemasi:

Q_1 — isitgichda olingan issiqlik miqdori;

Q_2 — sovitgichga berilgan issiqlik miqdori;

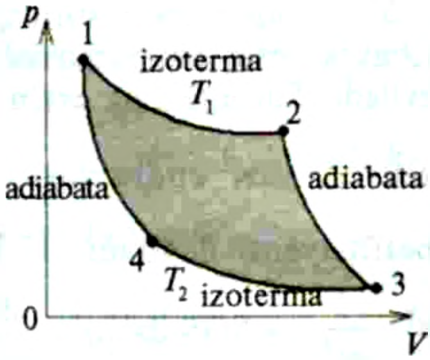
$A = Q_1 - Q_2$ — dvigatelning bajargan ishi.

4. Issiqlik mashinasining maksimal FIK:

$$\eta_{max} = \frac{T_1 - T_2}{T_1} \cdot 100\%.$$

5. Karno (fransuz injeneri, 1824-y.) sikli

$$\frac{Q_2}{Q_1}=\frac{T_2}{T_1}.$$



Ideal gaz mashinasi uchun Karno teoremasi, ya'ni issiqlik dvigatelining FIK ishchi jism turiga bog'liq emas, faqat T_1 va T_2 ga bog'liq:

$$\eta_{max}=\frac{T_1-T_2}{T_1}\cdot 100\%,\quad \eta_{max}=1-\frac{T_2}{T_1}=1-\frac{Q_2}{Q_1}.$$

Demak, $\eta_{max}<1$ (har doim), chunki, $T_1\to\infty$ va T_2 =OK bo'lmaydi.

6. Sovitkich mashinasining FIK yoki sovitish koeffitsiyenti:

$$\eta=\frac{Q_2}{A}\quad \text{yoki}\quad \eta=\frac{T_2}{T_1-T_2},$$

bu yerda Q_2 — olib ketilgan issiqlik miqdori, A — sarf qilingan ish.

Odatda, issiqlik dvigatellari uchun $\eta\approx 20-35\%$.

2.10. Suyuqliklarda sirt taranglik

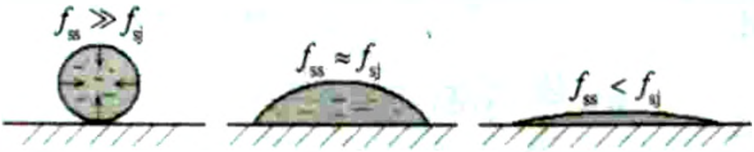
1. Suyuqlik sirtidagi molekulalarning o'zaro ta'siri va uning ichki qatlamidagi molekulalar bilan ta'siri natijasida suyuqlik sirtidagi molekulalarga suyuqlik ichiga yo'nalgan va suyuqlik sirtini kamaytirishga harakat qiluvchi kuch vujudga keladi. Bu kuch sirt taranglik kuchi deyiladi.

2. Suyuqlik erkin sirti chegarasining uzunlik birligiga ta'sir qiluvchi kuch $\sigma=\frac{F}{l}$ — sirt taranglik koeffitsiyenti deyiladi. Birligi: SI da $[\sigma]=\frac{\text{N}}{\text{m}}$, SGS da $[\sigma]=\frac{\text{dn}}{\text{sm}}$.

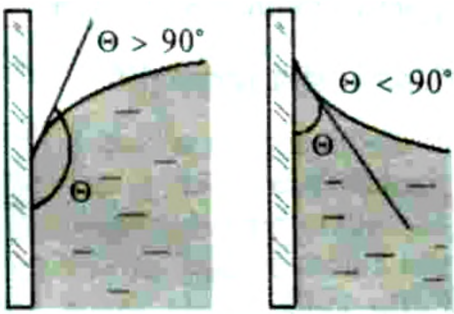
3. Suyuqlik erkin sirtidagi molekulalarning hajmiga nisbatan ortiqcha potensial energiyasi **sirt energiyasi** deyiladi. Suyuqlikning erkin sirtini yuza birligiga to'g'ri keluvchi sirt energiyasi $\sigma = \frac{W_p}{S}$ – sirt taranglik koeffitsiyenti deyiladi. U holda uning birligi SI da $[\sigma] = \frac{J}{m^2}$ va SGS da $[\sigma] = \frac{dn}{sm^2}$.

4. Sirt taranglik koeffitsiyenti:
a) suyuqlik turiga;
b) suyuqlik tarkibiga;
d) suyuqlik temperaturasiga;
e) suyuqlik sirtidagi muhitga bog'liq.

5. Ho'llash.



a) to'la ho'llamaslik b) qisman ho'llash d) to'la ho'llash



e) ho'llamaslikda va ho'llashda chegaraviy burchak va menisk

6. Kapillyar hodisalar.

$p_l = \frac{2\sigma}{r}$ – sirtning egrilanish natijasida vujudga keladigan bosim (Laplas bosimi).

$p_g = \frac{P_{og'}}{S} = \rho g h$ – gidrostatik bosim. $P_l = P_g$ dan

$\frac{2\sigma}{r} = \rho g h$ va $h = \frac{2\sigma}{\rho g r}$. Bu yerda ρ – suyuqlik zichligi, h – suyuqlik ko'tarish balandligi, g = 9,81 m/s^2.

a) ho'llash b) ho'llamaslik

7. Sirt taranglik koeffitsiyentini aniqlash usullari:

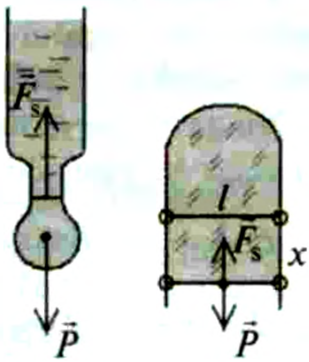
a) tomchi usuli: $P_{og'} \geq F_s$. $mg = \sigma \cdot l = \sigma \cdot 2\pi r$, $\sigma = \frac{mg}{2\pi r}$.
Bu yerda m – tomchi massasi, r – tomizg'ich radiusi;

b) bajarilgan ish usuli:

$$A = F_s \cdot x = \sigma \cdot 2l \cdot x = \sigma \cdot \Delta S.$$

$\sigma = \frac{A}{\Delta S}$ yoki $\sigma = \frac{F_s}{2l}$; bu yerda $\Delta S = 2l \cdot x$ – suyuqlik erkin sirti yuzasining o'zgarishi.

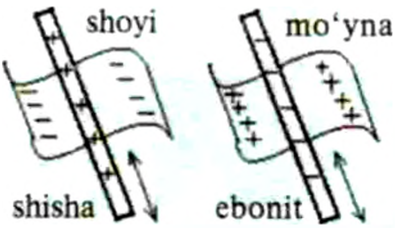
8. Sirt taranglik koeffitsiyenti suyuqlik temperaturasi ortishi bilan kamayadi. Sababi, T ortishi bilan molekulalar orasidagi masofa r ortadi, ular orasidagi ta'sir kuchlari kamayadi.



a) tomchi usuli b) bajarilgan ish usuli

3.1. Elektr zaryadi va maydoni

1. Elektr zaryadi – elektromagnit o'zaro ta'sir intensivligini xarakterlaydigan fizik kattalik. «Elektr» yunoncha «kahrabo» degan so'zni anglatadi.



Atomlarda manfiy zaryad tashuvchilar elektronlardir, musbat zaryadlar esa protonlardir.

Jismlar o'zaro ishqalanganda ularda elektronlarni taqsimoti o'zgarishi natijasida zaryadlanib qoladi.

2. Zaryad saqlanish qonuni: berk sistemada barcha jismlarni zaryadlarining algebraik yig'indisi doimiydir, ya'ni

$$q_1 + q_2 + q_3 + \ldots + q_n = \text{const yoki}$$

$$q_1 + q_2 + q_3 + \ldots + q_n = q_1' + q_2' + q_3' + \ldots + q_n' = \text{const},$$

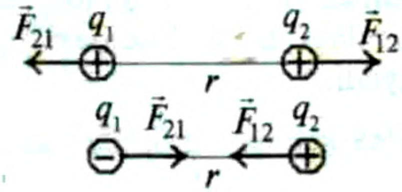
bu yerda $q_1, q_2, q_3, \ldots, q_n$ va $q_1', q_2', q_3', \ldots, q_n'$ – sistemadagi jismlarning o'zaro ta'sirlashishdan avvalgi va keyingi zaryadlari.

3. Kulon qonuni (1785-y). Qo'zg'almas zaryadlar maydonini o'rganuvchi elektrodinamikaning bo'limi **elektrostatika** deyiladi.

Nuqtaviy zaryadlarining o'zaro ta'sir kuchi Kulon qonuniga bo'ysunadi:

$$F \sim |q_1| \cdot |q_2|, \; F \sim \frac{1}{r^2} \text{ va}$$

$$F_{12} = F_{21} = F = k\frac{|q_1| \cdot |q_2|}{\varepsilon r^2},$$



bu yerda $k = \dfrac{1}{4\pi\varepsilon_0} = 9 \cdot 10^9 \dfrac{\text{N}\cdot\text{m}^2}{\text{C}^2}$, $\varepsilon_0 = 8{,}85 \cdot 10^{-12} \dfrac{\text{C}^2}{\text{N}\cdot\text{m}^2}$ – elektr doimiysi bo‘lib, vakuumning **absolut dielektrik singdiruvchanligi** deyiladi.

$\varepsilon = \dfrac{F_{\text{vakuum}}}{F_{\text{muhit}}}$ – muhitning nisbiy dielektrik singdiruvchanligi.

Zaryad birligi $[q]$ = 1 C = 1 A · 1 s o‘tkazgichdan 1 s da 1 A tok o‘tgandagi ko‘chgan zaryad miqdori.

4. Elektr maydon va uning kuchlanganligi.

Elektr kuchining ta’siri mavjud fazoning qismiga elektr maydoni deyiladi. Qo‘zg‘almas elektr zaryadlarining hosil qilgan maydoni elektrostatik maydon deyiladi.

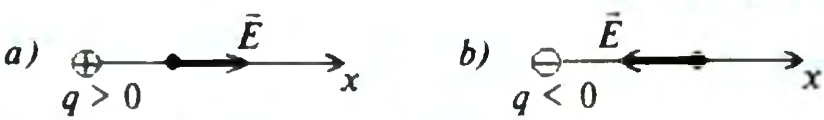
Elektr maydon xususiyati:

a) elektr zaryadi tomonidan hosil bo‘ladi;

b) zaryadga ta’sir qiladi va shunga asosan seziladi.

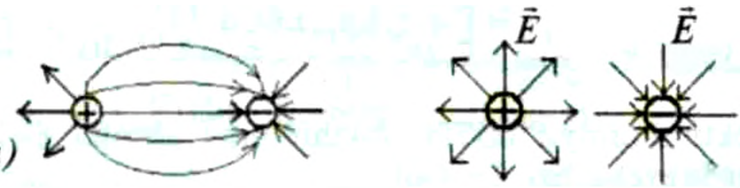
Elektr maydon kuchlanganligi $\bar{E} = \dfrac{\bar{F}}{q}$ – birlik musbat zaryadga ta’sir qiluvchi kuch maydonining shu nuqtasidagi kuchlanganligi deyiladi. Birligi: SI da $[E] = \dfrac{\text{N}}{\text{C}} = \dfrac{\text{V}}{\text{m}}$.

Elektr maydon kuchlanganligi vektorining yo‘nalishi:



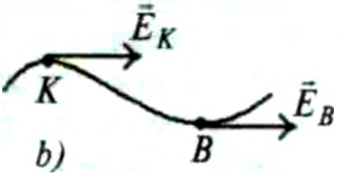
5. Elektr maydon kuch (kuchlanganlik) chiziqlari maydonni sxematik tasvirlash uchun ishlatiladi:

a) elektr maydon kuch chiziqlari (EMKCh) musbat zaryaddan boshlanib cheksizlikda yoki cheksizlikdan boshlanib manfiy zaryadda tugaydi yoxud musbat zaryaddan boshlanib manfiy zaryadda tugaydi;

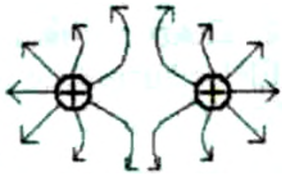


a)

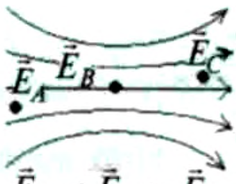
b) elektr maydon kuch chiziqlari shunday o'tkaziladiki, elektr maydon kuchlanganligi vektori uning ixtiyoriy nuqtasiga o'tkazilgan urinma bo'yicha yo'nalgan bo'ladi;



b)

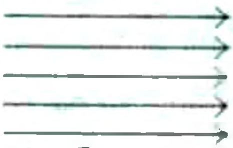


d)



$\vec{E}_A < \vec{E}_B > \vec{E}_C$

e)



f) $\vec{E}$ = const

d) elektr maydon kuch chiziqlari o'zaro kesishmaydi;

e) elektr maydon kuch chiziqlari maydon katta joyda zich, kichik joylarda siyrak o'tkaziladi;

f) barcha nuqtalarida maydon kuchlanganligi bir xil bo'lgan maydon bir jinsli maydon deyiladi va uning kuch chiziqlari bir xil zichlikda o'tkazilgan parallel to'g'ri chiziqlardan iboratdir.

6. Elektr maydon uchun superpozitsiya prinsipi o'rinli, ya'ni

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ... + \vec{E}_n = \sum_{i=1}^{n} \vec{E}_i .$$

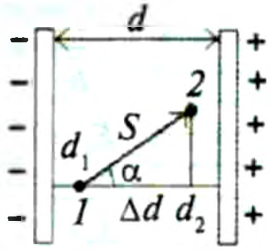
3.2. Elektr maydonda ish va potensial

1. Elektr maydonida zaryadni ko'chirishda bajarilgan ish:

$$A = F \cdot S \cdot \cos\alpha = q \cdot E(d_1 - d_2) = q \cdot E \cdot \Delta d,$$

$$A = F \cdot S \cdot \cos\alpha.$$

2. $A = qE(d_1 - d_2) = -(qEd_2 - qEd_1) =$
$= -(W_{p2} - W_{p1}) = -\Delta W_p.$



Elektrostatik maydonning bajargan ishi zaryadning potensial energiyasining kamayishiga teng. $W_p = q \cdot E \cdot d$ – bir jinsli elektr maydonidagi zaryadning potensial energiyasi.

3. Birlik musbat zaryadning maydonining biror nuqtasidagi potensial energiyasi maydonining shu nuqtadagi potensiali deyiladi:

$$\varphi = \frac{W_p}{q}, \ A = q(\varphi_2 - \varphi_1).$$

4. Birlik musbat zaryadni biror nuqtadan cheksizlikka ko'chirishda bajarilgan ish maydonning shu nuqtadagi potensiali deyiladi, ya'ni $\varphi = \frac{A_{1\to\infty}}{q} = \frac{W_{p1}}{q}$.

5. Elektr maydonining ikki nuqtasi orasidagi potensiallar farqi yoki kuchlanishi

$$\Delta\varphi = U = \varphi_1 - \varphi_2 = \frac{W_{p1} - W_{p2}}{q} = \frac{A}{q}$$

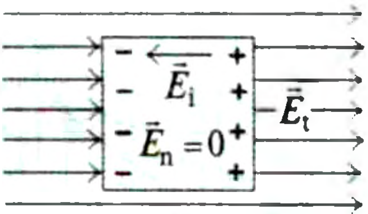
birlik musbat zaryad shu nuqtalar orasida ko'chirishdagi bajarilgan ishga teng. Bundan $A = q \cdot \Delta\varphi = q \cdot U$ va

$$\Delta\varphi = U = \ = E \cdot \Delta d, \ E = \frac{\Delta\varphi}{\Delta d} = \frac{\varphi_1 - \varphi_2}{d_1 - d_2}.$$

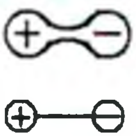
6. **Potensial birligi** $[\varphi] = \frac{1\ \text{J}}{1\ \text{C}} = 1\ \text{V}$.

7. **Elektr maydonda o'tkazgich.**

Izida elektr zaryadini erkin uzatadigan moddalarga o'tkazgichlar deyiladi. O'tkazgichlar: metallar, ishqor, tuz,



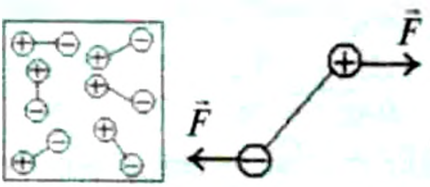
kislota eritmalari, ionlashgan bug' va gazlar. Elektr maydonga kiritilgan o'tkazgich sirtlarida zaryadlar to'planadi. Bu hodisaga elektrostatik induksiya deyiladi. O'tkazgich ichidagi natijaviy maydon $E_{nat} = E_{tashqi} - E_{ichki} = 0$. Bu hodisa elektrostatik himoyada ishlatiladi.



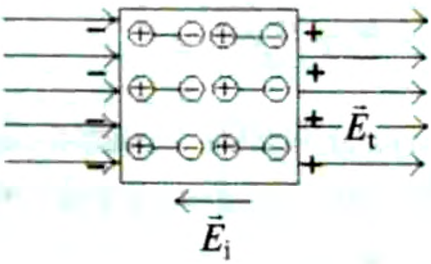
8. **Elektr maydonda dielektrik.**

O'zi orqali elektr zaryadini erkin uzata olmaydigan moddalar dielektriklar deyiladi.

Dielektriklar: ebonit, shisha, chinni, havo, toza suv va hokazo.



Zaryadlari teng, qarama-qarshi ishorali va bir-biri bilan mustahkam bog'langan nuqtaviy zaryadlar sistemasi dipol deyiladi.



Dipollarning tashqi maydon ta'sirida tartibli joylashish jarayoni **qutblanish** deyiladi:

$$\varepsilon = \frac{E_{tashqi}}{E_{nat}}$$

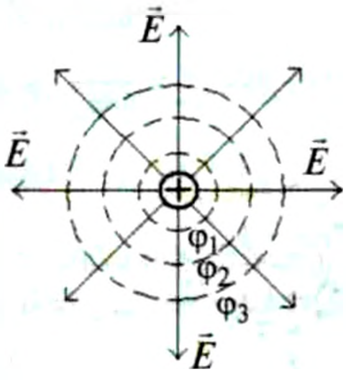
muhitning nisbiy dielektrik singdiruvchanligi bo'lib, muhitda elektr maydonining necha marta susayishini ko'rsatadi, demak, $\varepsilon = \frac{E_0}{E_n} = \frac{F_0}{F_n} = \frac{\varphi_0}{\varphi_n}$; chunki $F = q \cdot E$,

$$E_o = E_t, \quad F_o = F_t, \quad \varphi_0 = \varphi_t.$$

3.3. Potensial va kuchlanganlik

1. Nuqtaviy zaryadning elektr maydon kuchlanganligi

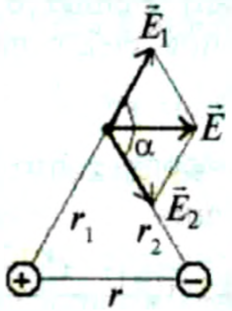
$$E = k\frac{q}{\varepsilon r^2} \quad \text{yoki} \quad E = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{\varepsilon r^2}$$

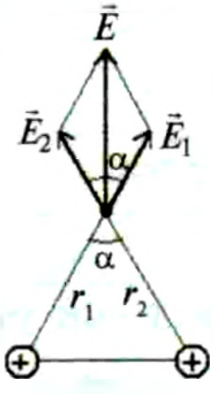


va potensiali $\varphi = k\frac{q}{\varepsilon r}$ yoki $\varphi = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{\varepsilon r}$. ε – muhitning nisbiy dielektrik singdiruvchanligi.

2. Ikkita nuqtaviy zaryadning natijaviy elektr maydon kuchlanganligi:

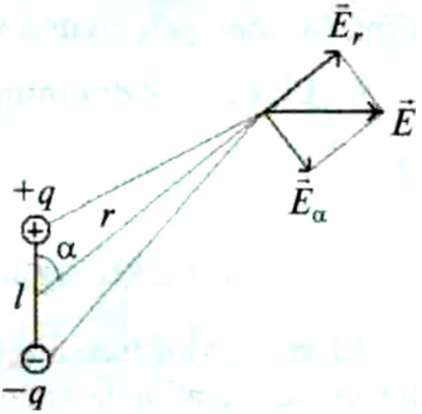
$$\vec{E}_n = \vec{E}_1 + \vec{E}_2 \quad \text{yoki} \quad E_n = \sqrt{E_1^2 + E_2^2 + 2E_1\cdot E_2\cos\alpha}\,.$$





3. Dipolning elektr maydon kuchlanganligi:

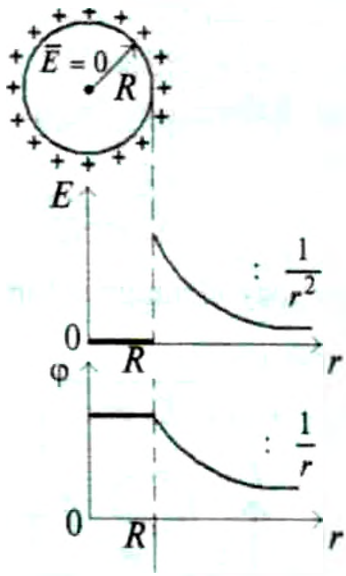
$$E = k\frac{P}{r^3}\sqrt{1 + 3\cos^2\alpha}\,.$$



Dipolning elektr maydon potensiali:

$$\varphi = k\frac{P}{r^2}\cdot\cos\alpha\ ,$$

bu yerda $k = \frac{1}{4\pi\varepsilon_0}$ va $p = q \cdot l$ – dipol momenti.



4. Zaryadlangan sharning elektr maydon kuchlanganligi:

$E = k\frac{q}{\varepsilon r^2}$ $(r \geq R)$ va $E = 0$ $(r < R$ bo‘lganda), potensiali $E = k\frac{q}{\varepsilon r^2}$ $(r \geq R)$ va $\varphi = k\frac{q}{\varepsilon R} = \text{const}$ $(r <$ R bo‘lganda).

5. Tekis zaryadlangan va zaryadning sirt zichligi σ bo‘lgan tekislikning elektr maydon kuchlanganligi:

$E = \frac{\sigma}{2\varepsilon_0} = \text{const}$, bu yerda $\sigma = \frac{q}{S}$ va S – sirt yuzasi, $\varepsilon_0 = 8{,}85\cdot 10^{-12}\,\frac{\text{C}^2}{\text{N}\cdot\text{m}^2}$ yoki F/m. Maydon potensiali $\varphi = E \cdot r$ (yoki $\varphi = E \cdot x$) ga teng.

6. Elektr maydonining muhitdagi kuchlanganligi:

$E = \frac{E_0}{\varepsilon}$, E_0 – vakuumdagi elektr maydon kuchlanganligi.

3.4. Elektr sig‘imi. Kondensatorlar

Elektr sig‘imi jismning o‘zida elektr zaryadini saqlab turish xususiyatini tavsiflaydi.

1. Zaryadlangan jismning elektr sig'imi: $C = \frac{q}{\varphi}$, bu yerda q – jismning zaryadi, φ – potensiali.

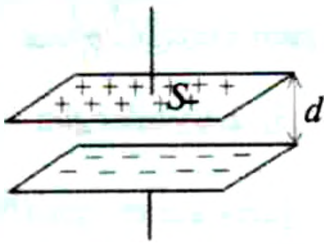
Birligi $1\ \text{F} = \frac{1\ \text{C}}{1\ \text{V}}$. Amaldagi birliklari: 1 μF (mikrofarada) = 10^{-6} F; 1 nF (nanofarada) = 10^{-9} F; 1 pF (pikofarada) = 10^{-12} F.

O'tkazgichning potensialini bir birlikka oshirish uchun zarur bo'lgan zaryad miqdoriga **o'tkazgichning elektr sig'imi** yoxud **sig'im** deyiladi: $C = \frac{\Delta q}{\Delta t}$.

O'lchamlariga nisbatan juda yaqin joylashtirilgan va dielektrik muhit bilan ajratilgan o'tkazgichlar sistemasiga **kondensator** deyiladi.

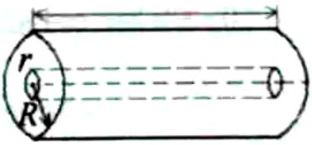
2. Kondensatorning sig'imi: $C = \frac{q}{U}$; U – kondensator qoplamalari orasidagi kuchlanish.

3. Yassi kondensator sig'imi:



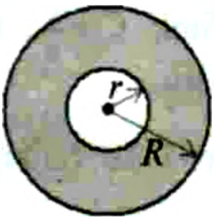
$C = \frac{\varepsilon_0 \varepsilon S}{d}$, bu yerda S – qoplamalar yuzasi; d – orasidagi masofa; e – muhitning nisbiy dielektrik singdiruvchanligi.

4. Silindrik kondensatorning sig'imi: $C = \frac{2\pi\varepsilon_0\varepsilon l}{\ln\frac{R}{r}}$, bu yerda l – silindrning uzunligi, R va r ichki va tashqi silindrlarning radiuslari.



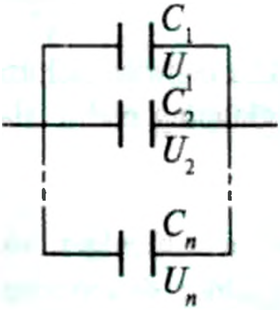
5. Sferik kondensatorning sig'imi:

$$C = \frac{4\pi\varepsilon_0\varepsilon}{\frac{1}{r} - \frac{1}{R}} \quad \text{yoki} \quad C = \frac{4\pi\varepsilon_0\varepsilon R \cdot r}{R - r}.$$



6. Shar sig'imi: $C = 4\pi\varepsilon_0\varepsilon r$, bu yerda r – sharning radiusi.

7. Kondensatorlarni parallel ulash:



$$C_{um} = C_1 + C_2 + C_3 + ... + C_n,$$

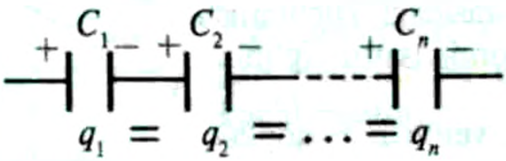
$$U_{um} = U_1 + U_2 + U_3 + ... + U_n.$$

n ta bir xil kondensator uchun $C_{um} = nC$.

8. Kondensatorlarni ketma-ket ulash.

$$\frac{1}{C_{um}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}.$$

n ta bir xil kondensatorlar uchun $C_{um} = \frac{C}{n}$.



9. Zaryadlangan kondensator energiyasi:

$$W = \frac{CU^2}{2} = \frac{q^2}{2C}.$$

10. Elektr maydonning energiya zichligi:

$$\omega = \frac{W}{V} = \frac{1}{2}\varepsilon\varepsilon_0 E^2,$$

bu yerda V – hajm, ε – muhitning dielektrik singdiruvchanligi.

3.5. Elektr toki

Zaryadlangan zarrachalarning har qanday tartibli harakatiga **elektr toki** deyiladi. Elektr tokining yo'nalishi qilib musbat zaryadlangan zarrachalar harakatining yo'nalishi qabul qilingan.

I. Tok kuchi: $I = \frac{\Delta q}{\Delta t}$ yoki $I_{o'rt} = \frac{q_{um}}{t}$, bu yerda:

Δq yoki q_{um} – o'tkazgich ko'ndalang kesimidan Δt yoki t vaqtda o'tgan zaryad miqdori. Demak, tok kuchi o'tkazgich ko'ndalang kesim yuzasidan vaqt birligida o'tgan zaryad miqdoridir.

Birligi $[I] = 1\ \mathrm{A} = \frac{1\ \mathrm{C}}{1\ \mathrm{s}}$; amaldagi birliklari:

1 kA = 10^3 A, sxemada – kA;
1 mA = 10^{-3} A, sxemada – mA;
1 mkA = 10^{-6} A, sxemada – μA;
1 nA = 10^{-9} A, sxemada – nA.

Tokning hosil bo'lish shartlari:

1. Zaryadlangan erkin zarrachalar bo'lishi.
2. Ularni batartib harakatga keltiruvchi maydon manbayi.
3. Zanjir berk bo'lishi kerak.

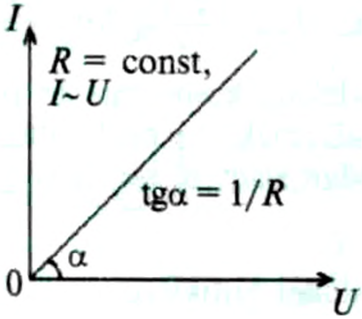
Tokning ta'siri:

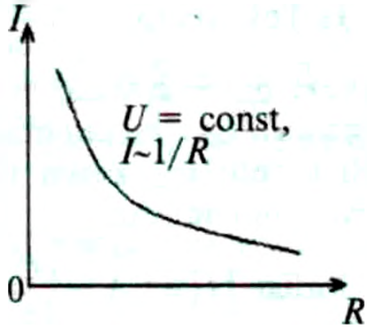
1. O'tkazgichdan tok o'tganda o'tkazgichning isishi – issiqlik ta'siri.
2. Tok atrofida magnit maydon hosil bo'lishi – magnit ta'siri.
3. Tokning kimyoviy ta'siri – elektroliz.

II. Tok zichligi: $j = \frac{I}{S}$; $j = nq_0 v$, birligi – $[j] = 1\frac{\mathrm{A}}{\mathrm{m}^2}$, bu yerda n – zaryad tashuvchi zarrachalarning konsentratsiyasi, q_0 – zaryadi, v – o'rtacha tezligi, s – elektrod yuzasi.

III. Zanjirning bir qismi uchun Om qonuni: $I = \frac{U}{R}$

(ya'ni $I \sim U$ va $I \sim 1/R$), bu yerda R – o'tkazgichning qarshiligi. Birligi $1\,\Omega = \frac{1\,V}{1\,A}$; 1 k$\Omega$ = 10^3 Ω, 1 MΩ = 10^6 Ω.

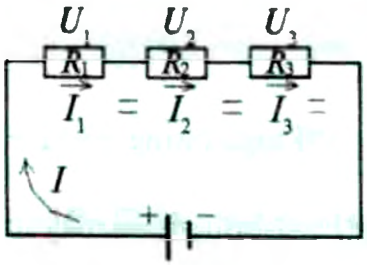




4. Bir jinsli o'tkazgichning qarshiligi: $R = \rho \frac{l}{S}$, bu yerda ρ – o'tkazgichning solishtirma qarshiligi, $[\rho] = \Omega \cdot m$; l – uzunligi va S – ko'ndalang kesim yuzasi.

Uzunligi 1 m va ko'ndalang kesim yuzasi 1 m^2 bo'lgan o'tkazgich qarshiligi solishtirma qarshilik deyiladi.

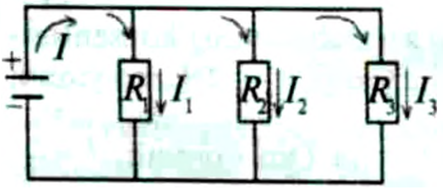
5. O'tkazgichlarni ketma-ket ulash:



$$U = U_1 + U_2 + U_3 =$$
$$= IR_1 + IR_2 + IR_3 = IR_{um},$$
$$R_{um} = R_1 + R_2 + R_3 \quad \text{yoki}$$
$$R = \sum_{i=1}^{n} R_i,$$

bir xil qarshiliklar uchun $R_{um} = nR$.

6. O'tkazgichlarni parallel ulash:



$$U = U_1 = U_2 = U_3;$$
$$U_1 = I_1R_1, \quad U_2 = I_2R_2,$$
$$U_3 = I_3R_3 \quad \text{va} \quad \frac{I_1}{I_2} = \frac{R_2}{R_1}$$

yoki $\dfrac{I_1}{I_2} = \dfrac{R_2}{R_1}$; $\quad I = I_1 + I_2 + I_3$ (Kirxgof qoidasi);

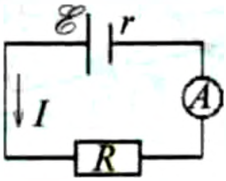
$$I_{um} = \frac{U_{um}}{R_{um}} = I_1 + I_2 + I_3 = \frac{U_1}{R_1} + \frac{U_2}{R_2} + \frac{U_3}{R_3};$$

$$\frac{1}{R_{um}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}; \qquad \frac{1}{R_{um}} = \sum_{i=1}^{n} \frac{1}{R_i};$$

agar qarshiliklar bir xil bo'lsa, $R_{um} = \dfrac{R}{n}$.

3.6. Butun zanjir uchun Om qonuni. Kirxgof qoidalari

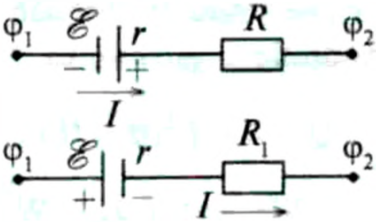
1. Butun zanjir uchun Om qonuni:



$I = \dfrac{\mathscr{E}}{R + r}$, ya'ni $I \sim \mathscr{E}$ va $I \sim \dfrac{\mathscr{E}}{R + r}$,

bu yerda $\mathscr{E}$ – manbaning EYK, R – zanjirdagi tashqi qarshilik, r – manbaning ichki qarshiligi.

2. Bir jinsli bo'lmagan zanjirda tok kuchi:



a) $I = \dfrac{U + \mathscr{E}}{R + r}$, chunki

$U = \varphi_1 - \varphi_2 = I(R + r) - \mathscr{E}$,

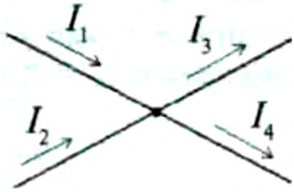
$\varphi_1 - \varphi_2 = \mathscr{E} - I(R + r)$;

b) $I = \dfrac{U - \mathscr{E}}{R + r}$, chunki

$U = \varphi_1 - \varphi_2 = I(R + r) + \mathscr{E}$.

3. Kirxgof qoidalari:

1) tugunga kelayotgan va tugundan ketayotgan toklarning algebraik yig'indisi nolga teng:



$I_{kel} + I_{ket} = 0$ yoki

$I_{kel} = -I_{ket}$.

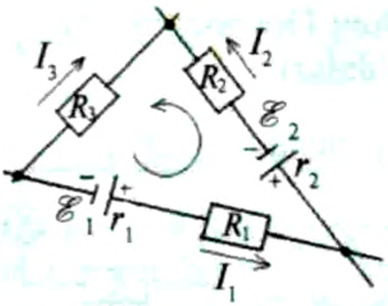
Masalan: $I_1 + I_2 - I_3 - I_4 = 0$ yoki $I_1 + I_2 = I_3 + I_4$.

2) Berk zanjirdagi kuchlanishlarning yig'indisi undagi tok manbalarining EYK larining algebraik yig'indisiga teng:

$$U_1 + U_2 + ... + U_n = \mathscr{E}_1 + \mathscr{E}_2 + ... + \mathscr{E}_n; \quad \sum U_i = \sum \mathscr{E}_i.$$

Masalan: $I_1(R_1 + r_1) + I_2(R_2 + r_2) - I_3 R_3 = \mathscr{E}_1 - \mathscr{E}_2$.

4. Elektr tokining ishi:



$A = IUt$ yoki $A = I^2Rt$

yoki $A = \frac{U^2}{R}t$, birligi:

1 J = 1 A · 1 V · 1 s, quvvati

$P = \frac{A}{t} = IU$ yoki $P = I^2R$

yoki $P = \frac{U^2}{R}$, birligi 1 W = 1 A · 1 V.

5. Joul-Lens qonuni. (Ta'rif: O'tkazgichdan elektr toki o'tganda ajralib chiqqan issiqlik miqdori tok kuchining kvadratiga, qarshilikka va vaqtga to'g'ri proporsional):

$$Q = A = I^2Rt = IUt = \frac{U^2}{R}t, \text{ ya'ni } Q \sim I^2,\ Q \sim R,\ Q \sim t.$$

1 W · s = 1 J, 1 W · soat = 3600 J = $3{,}6 \cdot 10^3$ J, 1 kW · soat = $3{,}6 \cdot 10^6$ J.

6. Tok manbayining EYK: $\mathscr{E} = \frac{A_{\text{chet}}}{q}$; $A_{\text{tashq}} = qIR = I^2Rt$;

$A_{\text{ichk}} = qIr = I^2rt$; bu yerda A_{chet} – tomonli (chet) kuchlarning q – zaryadni butun zanjir bo'yicha ko'chirishda bajargan ishi.

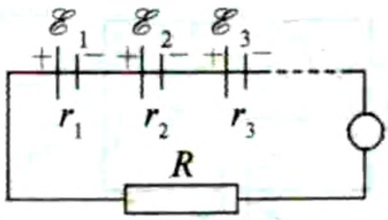
$$\eta = \frac{A_f}{A_t} = \frac{R_f}{R_t} = \frac{I^2R}{\mathscr{E}I} = \frac{R}{R+r}.$$

7. Tok manbayining FIK: $\eta = \frac{A_f}{A_t} = \frac{R_f}{R_t} = \frac{I^2 R}{\mathscr{E} I} = \frac{R}{R+r}$,
bu yerda A_f, R_f — foydali bajarilgan ish va quvvat; A_T, R_T — bajarilgan to'la ish va quvvat.

8. To'la maksimal quvvat: $P_{max} = \frac{\varepsilon^2}{4r}$.

9. Qisqa tutashuv toki: $I_{q.t.} = \frac{\mathscr{E}}{r}$, chunki $R = 0$. ($J = \frac{\varepsilon}{R_{tr}}$)

3.7. O'zgarmas tok qonunlarining tatbiqi

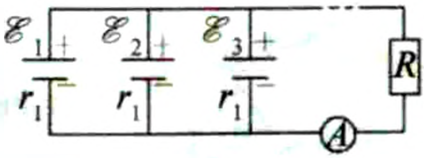


1. Tok manbalarini ketma-ket ulash:

$\mathscr{E} = \mathscr{E}_1 + \mathscr{E}_2 + \mathscr{E}_3 + ... + \mathscr{E}_n$.

Agar ular bir xil bo'lsa,

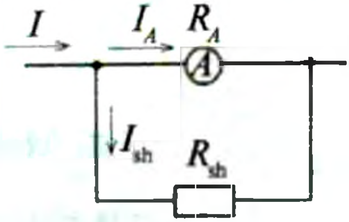
$\mathscr{E} = \mathscr{E}_1 n, \qquad I = \frac{\mathscr{E}_1 n}{R + r_1 n}$.



2. Tok manbalarini parallel ulash:

$\mathscr{E}_1 = \mathscr{E}_2 = \mathscr{E}_3, \qquad \mathscr{E} = \mathscr{E}_1$.

Bir xil bo'lsa, $I = \frac{\mathscr{E}_1}{R + \frac{r_1}{n}}$.



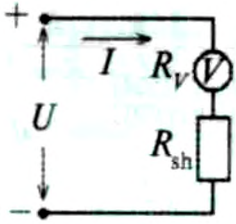
3. Ampermetrga shunt ulash.

Kirxgofning 1- qoidasiga asosan $I = I_A + I_{sh}$ va Om qonuniga asosan $I_A \cdot R_A = I_{sh} \cdot I_{sh}$.

Bundan $R_{sh} = \frac{I_A R_A}{I - I_A}$.

O'lchash intervalini n marta oshirish uchun

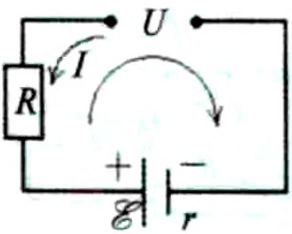
$$R_{sh} = \frac{R_A}{n-1}.$$



4. Voltmetrga shunt ulash: $I_V = I_{sh} = I$ (toklar bir xil) va $U = U_V + U_{sh} =$ $= U_V + I \cdot R_{sh} = U_V + \frac{U_V}{R_V} \cdot R_{sh}$;

$$R_{sh} = \frac{U - U_V}{U_V} \cdot R_V = \left(\frac{U - U_V}{U_V} - 1 \right) \cdot R_V.$$

Voltmetrning o'lchash intervalini n marta oshirish uchun $R_{sh} = (n - 1)R_V$.

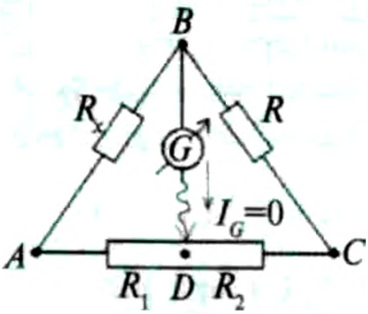


5. Bir jinsli bo'lmagan zanjir uchun Om qonuni:

$$I = \frac{U + \mathscr{E}}{R + r},$$

bu yerda $U = \varphi_1 - \varphi_2$.

6. Akkumulatorni $I = \dfrac{U - \mathscr{E}}{R + r}$ zaryadlashdagi tok kuchi.



7. Uitson ko'prigi yordamida qarshiliklarni aniqlash. Galvanometrdan o'tayotgan tok kuchi nolga teng bo'lganda ko'prik muvozanatda bo'ladi va bu hol uchun

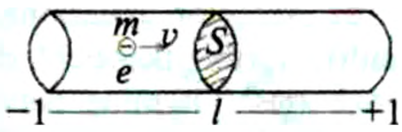
$\varphi_B = \varphi_D$ hamda $R_X = \dfrac{R_1}{R_2} \cdot R$.

3.8. Metallarda elektr toki

1. Metallarda elektr toki – bu elektronlarning batartib harakatidir:

$$e = 1{,}6 \cdot 10^{-19}\ \mathrm{C},$$
$$m_0 = 9{,}1 \cdot 10^{-31}\ \mathrm{kg}$$

(L. Mandelshtam, N. Papaleksi, T. Styuart, R. Tolmen.) S — yuzadan og'ib o'tgan zaryad miqdori $\Delta q = enSv\Delta t$

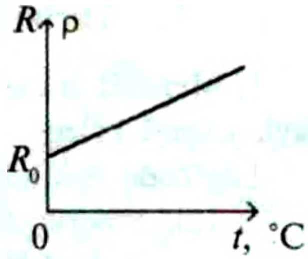


tok kuchi $I = \frac{\Delta q}{\Delta t} = en\bar{v}S$, bu yerda e — elektron zaryadi; n — konsentratsiyasi, v — o'rtacha tezligi.

2. O'tkazgichning qarshiligi: $R = \rho\frac{l}{s}$;

bu yerda ρ — o'tkazgichning solishtirma qarshiligi, birligi

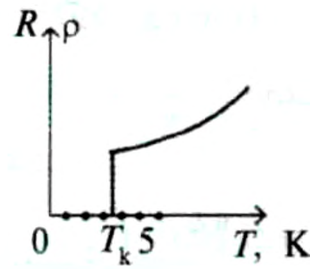
$[\rho] = \frac{[R][S]}{[l]} = \Omega \cdot m$, texnikada — Om · mm²/m.



3. Metallar qarshiligining temperaturaga bog'liqligi:

$$R = R_0(1 + \alpha t) \text{ yoki}$$
$$\rho = \rho_0(1 + \alpha t),$$

bu yerda R_0 — 0° dagi qarshiligi; ρ_0 — 0° dagi solishtirma qarshiligi; α — qarshilikning temperaturaviy koeffitsiyenti.



4. O'ta o'tkazuvchanlik: absolut harorat $T \to 0°$ K da $R \to 0$ yoki $\rho \to 0$.

5. Yarimo'tkazgichlarda elektr toki.

a) sof yarim o'tkazgichlarda elektr toki — elektronlar va kovaklar (teshiklar)ning batartib harakatidir.

b) Donor aralashmali [A (4 valentli) +B (5 valentli)] yarimo'tkazgichlarda (n- tur) elektr toki asosan elektronlarning batartib harakatidir.

d) Akseptor aralashmali [A (4 valentli) + C (3 valentli)] yarimo'tkazgichlarda [p- tur] elektr toki asosan kovak (teshik)larning batartib harakatidir.

e) Yarimo'tkazgich qarshiligining temperaturaga bog'liqligi: $R, \rho \sim \frac{1}{T}$.

6. Yarimo'tkazgichli asboblar: diod, tranzistor, termorezistor, fotorezistor, tiristor, integral sxemalar.

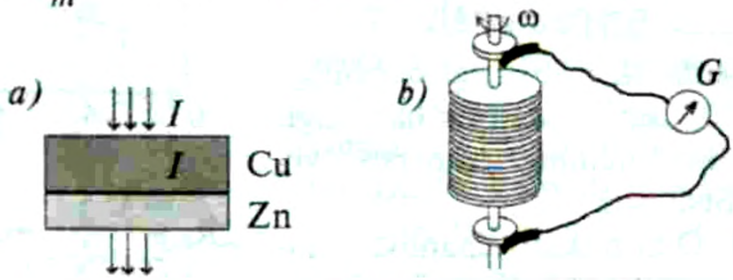
3.9. Yarimo'tkazgichlarda elektr toki

1. Metallarda elektr toki elektron o'tkazuvchanlik tufayli yuzaga keladi.

Tajribada tasdiqlanishi:

a) Rikke tajribasi;

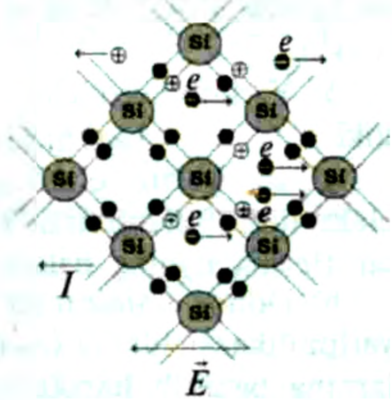
b) L.I. Mandelshtam va N.D. Papaleksi (1913), Styuart va Tolmen (1916) tajribada elektronning solishtirma zaryadi $\frac{e}{m} = 1{,}8 \cdot 10^{11}$ C/kg ni aniqladilar.



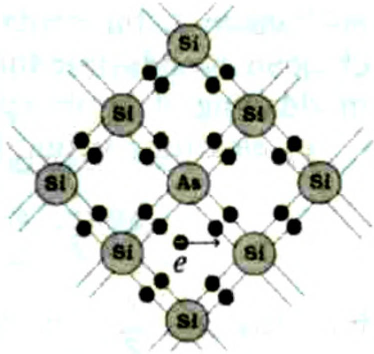
2. Yarimo'tkazgichlarda elektr toki.

Xususiy yarimo'tkazgichlarda elektr toki elektron va kovaklarning batartib harakatidir $j = j_{el} + j_{kovak}$.

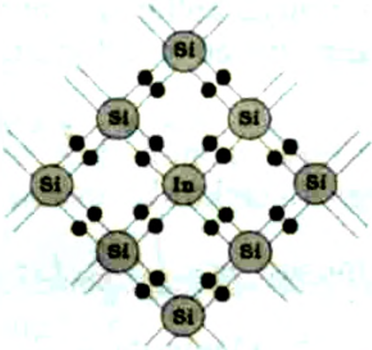
$Si^4 + A^5 \Rightarrow n$- turdagi (donor aralashmali yarimo'tkaz-



gich) elektronlar asosiy zaryad tashuvchi, kovaklar (teshiklar) asosiy bo'lmagan yarimo'tkazgich materiallar *elektronli* yoki *n-turdagi yarimo'tkazgichlar* deyiladi.



$Si^4 + B^3 \Rightarrow$ *p*-turdagi (aksentor aralashmali yarimo'tkazgich). Kovaklar konsentratsiyasi o'tkazuvchanlik elektronlari konsentratsiyasidan ortiq bo'lib, elektronlarni tutib, harakatchan kovaklar hisobiga elektr o'tkazuvchanlikka ega bo'lgan materiallar kovakli (teshikli) yoki *p-tur yarimo'tkazgichlar* deyiladi.



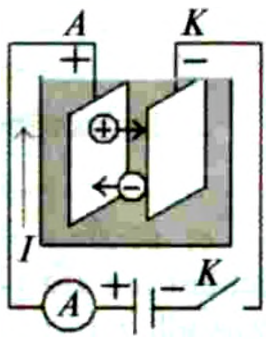
3.10. Suyuqliklarda elektr toki

1. Elektrolitlarda elektr toki – musbat va manfiy ionlarning batartib harakati:

a) elektrolit – o'zidan elektr toki o'tkazadigan tuz, ishqor, kislota va boshqa birikmalarning eritmasi.

Elektrolitlarda moddalarning ionlarga ajralishi elektrolitik **dissotsiallanish** deyiladi.

Masalan: $CuSO_4 \rightarrow Cu^{+2} + SO_4^{-2}$.



Elektrolitlarda – ion o'tkazuvchanlikdir;

b) elektroliz – elektrolitdan elektr toki o'tganda elektrodlarda moddalarning ajralib to'planishi;

d) elektroliz uchun Faradeyning I qonuni $m = k \cdot q = k \cdot I \cdot t$, ya'ni

$m \sim I$ va $m \sim t$, bu yerda m – elektroliz vaqtida ajralib chiqqan modda miqdori; I – tok kuchi; t – vaqt; k – moddaning elektrokimyoviy ekvivalenti, birligi kg/C;

e) elektroliz uchun Faradeyning II qonuni:

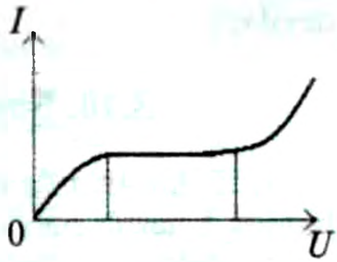
$$k = \frac{1}{F} \cdot X = \frac{1}{F} \cdot \frac{A}{Z}, \text{ ya'ni } k \sim X,$$

bu yerda $X = \frac{A}{Z}$ – moddaning kimyoviy ekvivalenti; A – atom (molyar) massasi, Z – valentligi; F – Faradey doimiysi bo‘lib, 1 mol modda ajralishi uchun zarur bo‘lgan zaryad miqdoridir:

$$F = N_A \cdot e = 96485{,}309 \approx 96500\ \mathrm{C/mol}$$

f) elektroliz uchun Faradeyning umumlashgan formulasi: $m = \frac{1}{F} \cdot \frac{A}{Z} \cdot I \cdot t$.

2. Gazlarda elektr toki – musbat ionlar (qisman manfiy ionlar) va elektronlarning batartib harakati:



a) gazlarda elektr toki – gaz razryadi (chaqnashi)dir;

b) gaz razryadi $\begin{cases} \text{nomustaqil} \\ \text{mustaqil} \end{cases}$

d) ionlashtirish $\begin{cases} \text{termik ionlashtirish} \\ \text{elektron zarb bilan ionlash} \\ \text{fotonionlash} \end{cases}$

e) plazma – atom va molekulalarning ko‘p qismi ionlashgan gaz ($T \geq 10^5$ K) va undagi musbat va manfiy zaryadli zarrachalar soni deyarli bir xil.

Razryadlar (chaqnashlar):
- uchqun razryad, yashin
- miltillama razryad
- yoy razryad
- toj razryad

3. Gazlarda elektr tokining qo‘llanishi:
a) kunduzgi yorug‘lik lampalari;
b) lazerlar;
d) plazmatronlar;
e) MGD-generatorlar.

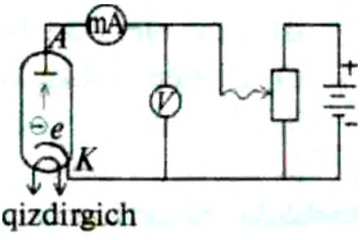
3.11. Vakuumda elektr toki

1. Vakuum – bu sirtidagi gazning shunday siyraklashishiki, unda molekulalarning erkin yugurish yo‘li idish o‘lchamlaridan katta bo‘ladi ($\lambda > D$).

2. Vakuumda elektr toki – elektronlarning (musbat va manfiy ionlarining) batartib harakatidir.

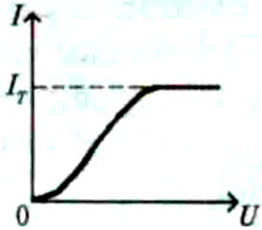
3. Jismlar qizdirilganda undan elektronlarning ajralib chiqish hodisasiga termoelektron emissiya (TEE) deyiladi.

4. TEE hodisasini vakuumli ikki elektroddan tashkil topgan elektron lampa yordamida o‘rganiladi.



Katod qizdirilganda, undan chiqqan elektronlar anod kuchlanishi ta’sirida harakat qiladi va TEE tokini hosil qiladi.

To‘yinish tokining kattaligi Richardson–Deshman formulasi bilan aniqlanadi:



$$I_T = BST^2 e^{-\frac{A}{kT}};$$

bu yerda $B = 120{,}4$ A/sm^2 · K^2

– Richardson–Deshman doimiysi; S – katod yuzasi; T – katod temperaturasi; k – Bolsman doimiysi, A – chiqish ishi.

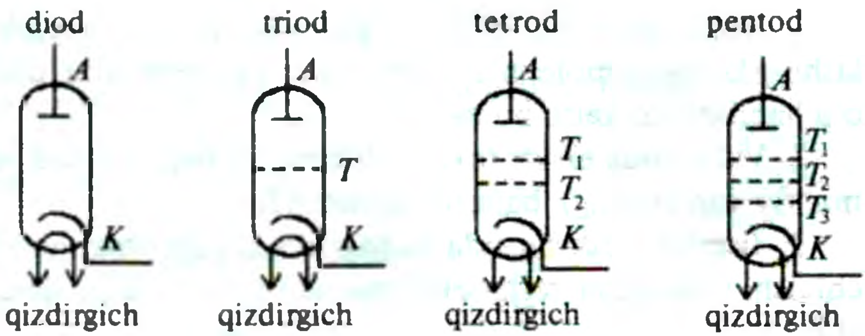
5. Elektronning chiqish ishini hisoblash (Richardson–Deshman) formulasi:

$$A = \frac{kT}{\lg e}\left[\lg B + \lg S + 2\lg T - \lg I_T\right] =$$

$$= \frac{T}{5040}\left[2{,}08 + \lg S + 2\lg T - \lg I_T\right].\ [\mathrm{A}] = \mathrm{eV}$$

6. Termoelektron asboblar:

a) elektron lampalar: diod, triod, tetrod va b.;



b) elektron-nurli trubka: ossillograf, televizor, EHM-monitor;

d) gazli elektron lampalar: tiratron, stabilitron;

e) rentgen trubka (nay).

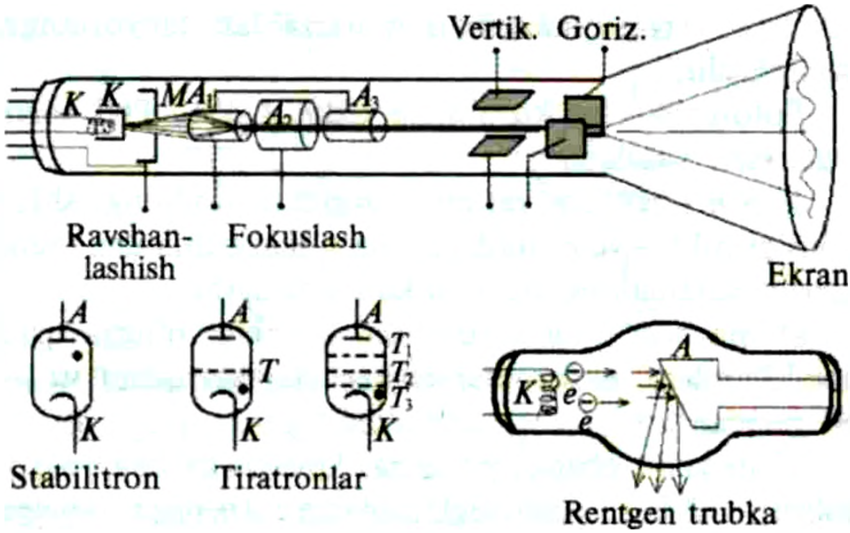
7. Elektron-nurli trubka (nay).

8. Elektron dasta (elektron, katod nurlari) – bu katta tezlikda harakatlanuvchi elektronlar oqimi.

Elektron dastaning xususiyatlari:

a) luminafor moddalarga urilganda nurlanish – yoritish hosil qiladi;

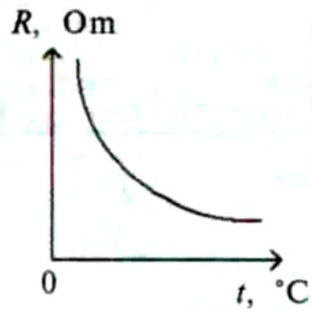
b) qattiq va suyuq jismlarga urilganda chaqnash hosil qiladi;



d) elektron dasta jismga urilib uni qizdiradi, eritadi, kesadi;

e) elektron dasta elektr va magnit maydonlarida og'adi.

3.12. Yarimo'tkazgichli asboblar



Yarimo'tkazgichlar – bu solishtirma qarshiligi temperatura oshishi bilan keskin kamayadigan moddalardir. Germaniy, kremniy, selen va boshqalar.

1. Yarimo'tkazgichli materiallarning qarshiligini temperaturaga bog'liqligiga asoslangan qarshiliklar termorezistorlardir. Termorezistorlar – metallarning – Ti, Mg, Ni, Mn, Co va boshqalarning oksidlarining aralashmasidan iborat yarimo'tkazgichli materiallardan tayyorlanadi.

2. Fotorezistorlar – yorug'lik nuri ta'sirida, uning intensivligiga bog'liq holda qarshiligi sezilarli o'zga-

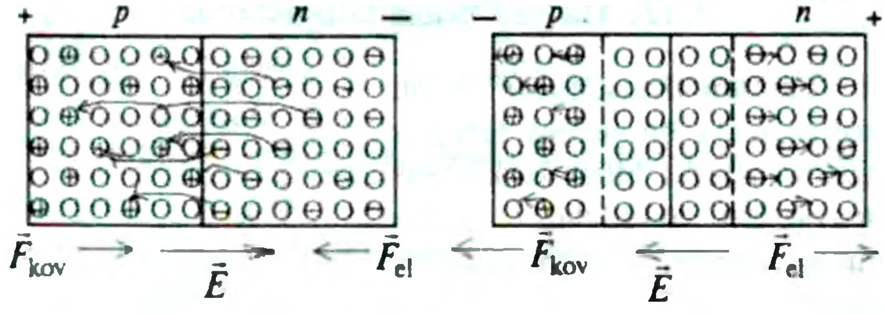
ruvchan yarimo'tkazgichli materialdan tayyorlangan qarshilikdir.

Fotorezistorlar ko'pincha CdS, CdSe, PbS birikmalaridan yasaladi.

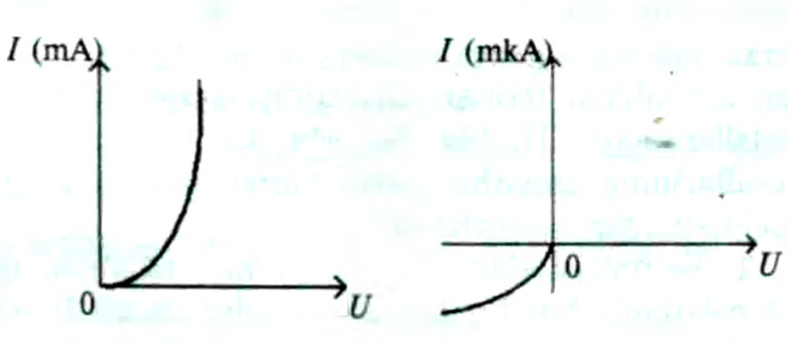
3. *p-n* o'tish va yarimo'tkazgichli diodning ishlash prinsipi yoki *p*- va *n*- turdagi yarimo'tkazgichlardan tashkil topgan sistemaning elektr tokini o'tkazishi:

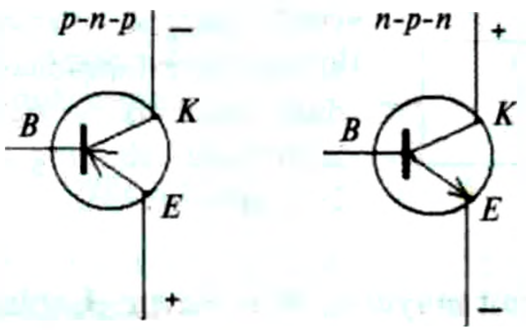
a) maydon o'ngga yo'nalsa, kovaklar o'ngga qarab harakat qiladi, elektronlar chapga harakat qiladi va *p-n* chegaradan $j = j_{el} + j_{kov}$ tok o'tadi;

b) maydon chapga yo'nalsa, kovaklarga chapga yo'nalgan kuch ta'sir etadi, elektronlarga esa o'ngga yo'nalgan kuch ta'sir etadi. Natijada *p-n* o'tish chegarasida elektr o'tkazuvchi zarrachalar soni keskin kamayadi va uning qarshiligi keskin ortib ketadi. *p-n* o'tish chegarasidan teng deyarli o'tmaydi. Yarimo'tkazgichli diodlar shu prinsipga asosan ishlaydi va tokni bir tomonga o'tkazadi.



a) b)



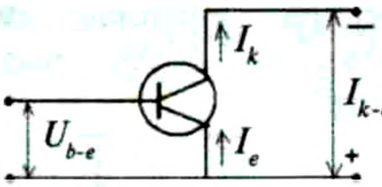


4. Tranzistor ikki xil: *p-n-p* va *n-p-n* turlarda bo'ladi.

a) *p-n-p* turdagi sistemani hosil qilish uchun Si-elektron o'tkazuvchanlikka ega bo'lgan monokristallni ikki yog'iga 3 valentli, masalan, indiy atomlari diffuziyalanib kiritiladi va *p*-o'tkazuvchanlik hosil qilinadi. Uning o'rta qismi *baza-asos* deyiladi;

b) *n-p-n* hosil qilish uchun uning kollektori va emmitteri Si ga 5 valentli metall atomlari diffuziyalanib hosil qilinadi. Bazasi esa *p*-akseptor o'tkazuvchanlikka ega.

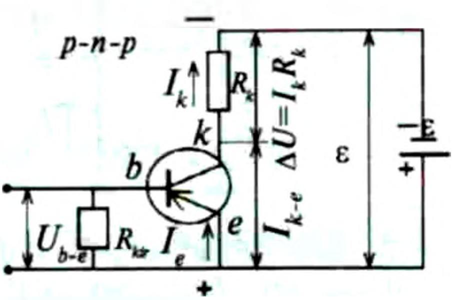
d) 1) Tranzistorning kuchaytirish xossalari:



$\beta = \dfrac{\Delta I_k}{\Delta I_b}$ tok bo'yicha kuchaytirish koeffitsiyenti;

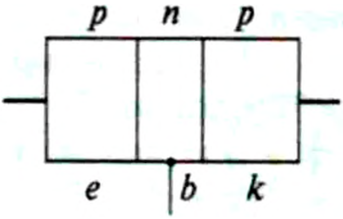
$$K_t = \frac{\Delta I_{chiq}}{\Delta I_{kir}} = \frac{\Delta I_k}{\Delta J_b} = \beta,$$

$I_k \approx \beta I_b$, $\beta = 20 \div 200.$



2) Kuchlanish bo'yicha signalni kuchaytirish koeffitsiyenti:

$$k_k = \frac{\Delta U_{chiq}}{\Delta U_{kir}} = \frac{\Delta I_k \cdot R_k}{\Delta I_e \cdot R_{kir}} = \beta \frac{R_k}{R_{kir}}.$$



3) Integral mikrosxemalarda bir necha minggacha tranzistor, diod, qarshilik va sig'imlar joylashtiriladi, ularning o'lchamlari 2–5 mkm bo'ladi.

3.13. Magnit maydon. Bio–Savar–Laplas qonuni

Magnit kuch ta'siri mavjud bo'lgan fazo qismiga **magnit maydon** deyiladi.

1. Magnit maydon hosil qilish usullari:

a) doimiy magnit yordamida;

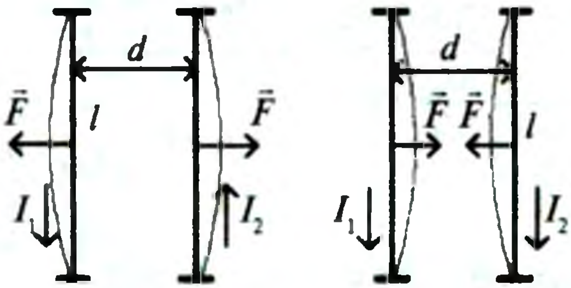
b) tokli o'tkazgich yordamida;

d) zaryadli zarralar dastasi yordamida.

Magnit maydon tokli o'tkazgichga ta'siri orqali hamda harakatlanuvchi zaryadli zarrachalarga ta'siri seziladi va o'lchanadi.

2. Toklar o'zaro magnit ta'sir kuchi: $F = \mu\mu_0 \dfrac{I_1 \cdot I_2 \cdot l}{2\pi d}$,

bu yerda μ – muhitning nisbiy magnit singdiruvchanligi, $\mu_0 = 4\pi \cdot 10^{-7}$ N/A^2 – magnit doimiysi, l – o'tkazgich uzunligi.

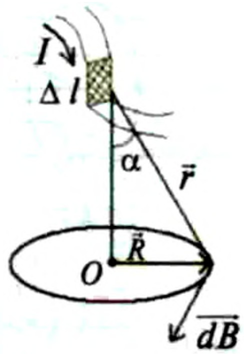


3. Bio–Savar–Laplas qonuni.

Uzunligi Δl bo'lgan tokli o'tkazgichdan r masofadagi magnit maydon induksiyasi:

$$\Delta B = \frac{\mu\mu_0}{4\pi} \cdot \frac{I \cdot \Delta l \cdot \sin\alpha}{r^2}.$$

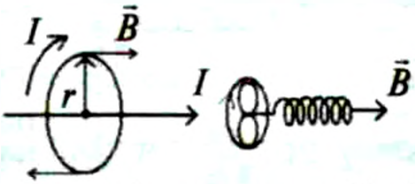
4. R radiusli, I tokli doiraviy o‘tkazgich markazidagi magnit maydon induksiyasi:



$$\Delta B = \mu\mu_0 \frac{I}{2R}.$$

5. Cheksiz uzun to‘g‘ri I tokli o‘tkazgichning magnit maydon induksiyasi:

$$\Delta B = \mu\mu_0 \frac{I}{2\pi r}.$$

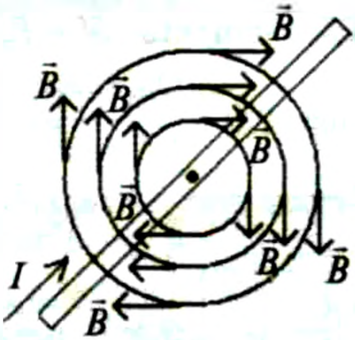


o‘ng parma qoidasi

6. Solenoid (cheksiz uzun tokli g‘altak)ning magnit maydon induksiyasi:

$$B = \mu\mu_0 \frac{I \cdot N}{l} = \mu\mu_0 In,$$

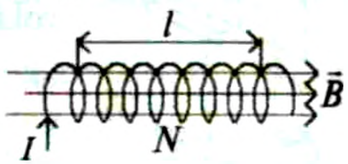
bu yerda $n = \frac{N}{l}$ – uzunlik birligidagi o‘ramlar soni.



7. B ning birligi Tl (tesla) (N. Tesla, 1856–1943):

$$1\ \text{mTl} = 10^{-3}\ \text{Tl},$$

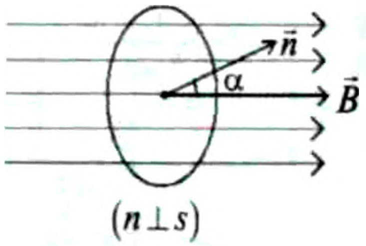
$$1\ \text{mkTl} = 10^{-6}\ \text{Tl}.$$



3.14. Magnit oqimi. Amper qonuni

1. Magnit oqimi Φ – biror yuzadan birlik vaqtda oqib o‘tuvchi ΔW magnit maydon energiyasidir, ya’ni $\Phi = \frac{\Delta W}{\Delta t}$, $[\Phi]$ = Vb (veber) = 1 J/1 s.

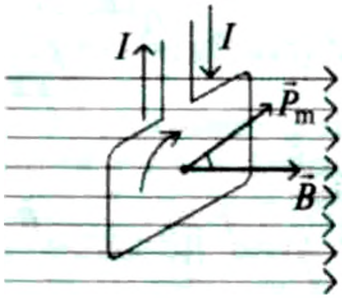
2. S yuzadan oqib o‘tuvchi magnit oqimi $\Phi = BS\cos\alpha$,



$\angle\alpha = (B^\wedge n)$ yoki $\Phi = B \cdot S_\perp$,

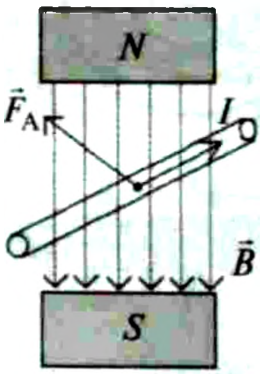
bundan $B = \dfrac{\Phi}{S_\perp}$, birligi

$$1\ \text{Tl} = \frac{1\ \text{Vb}}{1\ \text{m}^2}.$$

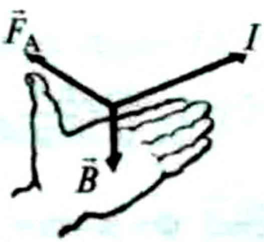


3. Tokning magnit momenti $P_m = I \cdot S$ yoki $P_m = I \cdot S \cdot \vec{n}$, bu yerda S – I tok o'tayotgan konturning yuzasi. $\vec{P}_m$ – yo'nalishi o'ng Parma qoidasi bilan aniqlanadi.

4. Magnit maydondagi I tokli ramkaga ta'sir qiluvchi kuch momenti: $M = P_m \cdot B \cdot \sin\alpha$ yoki $\vec{M} = \left[\vec{P}_m \cdot \vec{B}\right]$, birligi $1\ \text{Tl} = \dfrac{1\ \text{N} \cdot 1\ \text{m}}{1\ \text{A} \cdot 1\ \text{m}^2} = \dfrac{1\ \text{N}}{\text{A} \cdot \text{m}}$.

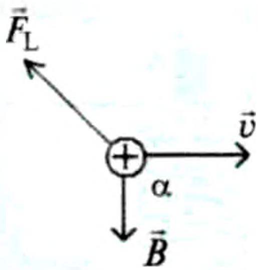


5. Amper qonuni: magnit maydonning uzunligi l bo'lgan, I tokli o'tkazgichga ta'sir etuvchi kuchi $F_A = IBl\sin\alpha$ yoki $\vec{F}_A = I\left[\vec{l} \cdot \vec{B}\right]$. Bu yerda α – $\vec{l}$ bilan $\vec{B}$ orasidagi burchak. $\vec{F}_A$ ning yo'nalishi chap qo'l qoidasi bilan aniqlanadi: *chap qo'l shunday joylashtiriladiki, unda ochilgan to'rtta barmoq tok yo'nalishi bilan mos tushsin. Magnit maydon induksiya chiziqlari esa kaftga tik yo'nalsin va unda to'g'ri burchakka ochilgan bosh barmoq Amper kuchi yo'nalishini ko'rsatadi.*



$$B = \frac{F_{max}}{I \cdot l}, \text{ birligi } 1\ \text{Tl} = \frac{1\ \text{N}}{\text{A} \cdot \text{m}}.$$

6. Lorens kuchi: magnit maydondan υ tezlik bilan harakatlanayotgan q zaryadga ta'sir kuchi



$$F_L = q_0 \upsilon B \sin\alpha \text{ yoki}$$

$$\vec{F}_L = q_0 \left[\vec{\upsilon} \cdot \vec{B}\right],$$

bu yerda $\angle\alpha = (B \hat{} \upsilon)$.

Ta'sir etuvchi kuchning yo'nalishi musbat zarracha uchun chap qo'l qoidasi, manfiy zarracha uchun o'ng qo'l qoidasi bilan aniqlanadi.

7. Magnit maydonda harakatlanayotgan zaryadli zarracha trayektoriyasining egrilik radiusi: $R = \frac{m\upsilon}{|q|B}$, bu yerda m – zarrachaning massasi, aylanish davri esa $T = 2\pi\frac{m}{|q|B}$.

3.15. Magnit maydonida modda. Faradey qonuni

1. Magnit maydonda modda. Magnit singdiruvchanlik. Bir jinsli magnit maydon induksiyasining qiymati B vakuumdagi qiymati B_0 dan necha marta farq qilishini ko'rsatuvchi kattalik *muhitining magnit singdiruvchanligi* μ deyiladi: $\mu = \frac{B}{B_0}$, bu yerda B_0 – vakuumdagi, B – muhitdagi magnit maydon induksiyasi:

a) $\mu < 1$ modda – diamagnit, $B < B_0$;

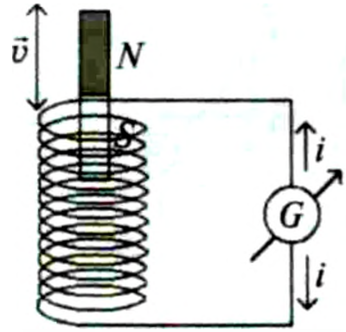
b) $\mu \geq 1$ – paramagnit, $B \geq B_0$;

d) $\mu \gg 1$ – ferromagnit, $B \gg B_0$.

2. **Kyuri temperaturasi** – modda ferromagnetikligini yo'qotib paramagnitga aylanuvchi temperaturadir.

3. **Elektromagnit induksiya qonuni (Faradey qonuni)**:

a) yopiq zanjirli konturni vaqt bo'yicha o'zgaruvchan magnit oqimi kesib o'tsa, zanjirda induksion EYK vujudga



keladi. Bu hodisa elektromagnit induksiya hodisasi deyiladi;

b) induksion EYK konturni kesib o'tuvchi magnit oqimining vaqt birligida o'zgarishiga teng:

$$\mathscr{E}_i = -\frac{\Delta\Phi}{\Delta t} \text{ yoki } \mathscr{E}_i = -\frac{d\Phi}{dt},$$

N ta o'ramlar sistemasi uchun

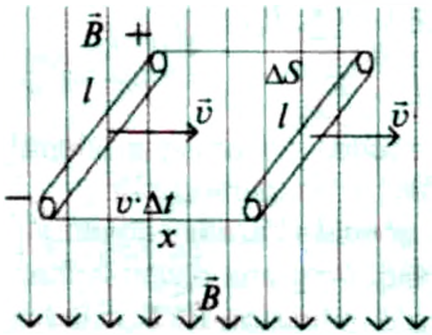
$\mathscr{E}_{i.um} = -N\frac{d\Phi}{dt}$; bu yerda $\mathscr{E}_i$ – induksion EYK; $\frac{\Delta\Phi}{\Delta t} \approx \frac{d\Phi}{dt}$ magnit oqimning o'zgarish tezligi. (–) ishora induksion tok yo'nalishini – Lens qoidasini xarakterlaydi.

Lens qoidasi: induksion tokning yo'nalishi shunday bo'ladiki, uning hosil qilgan magnit maydoni tashqi magnit maydonini o'zgartirishini kompensatsiyalashga intiladi.

4. G'altakdagi induksiya EYK. G'altakning o'ramlarni kesib o'tuvchi magnit oqimi $\Phi_{um} = N\Phi$ va unda vujudga keluvchi EYK $\mathscr{E}_i = -N\frac{d\Phi}{dt}$. Birligi $[\Delta\Phi] = [\mathscr{E}_i] \cdot [\Delta t]$ yoki

1 Vb = 1 V · 1 s, 1 V = 1 Vb/1 s.

5. Magnit maydonida harakatlanayotgan o'tkazgichdagi induksiya EYK.



$$\mathscr{E}_i = -\frac{d\Phi}{dt} = -\frac{B \cdot \Delta S \sin\alpha}{\Delta t} =$$

$$= -\frac{Bl\sin\alpha \cdot v \cdot \Delta t}{\Delta t} = -Blv\sin\alpha.$$

Induksion tokning yo'nalishi o'ng qo'l qoidasi bilan aniqlanadi.

O‘tkazgich uchlaridagi potensiallar farqi:

$$\Delta\varphi = |\mathcal{E}_i| = Blv\sin\alpha\,,$$

$$\angle\alpha = \left(\vec{B}\,\hat{}\,\vec{v}\right).$$

3.16. O‘zinduksiya hodisasi

1. Induktivlik.

O‘tkazgich yoki g‘altakdan I tok o‘tganda hosil bo‘luvchi magnit oqimi $\Phi = L \cdot I$, bu yerda L – induktivlik, $L = \frac{\Phi}{I}$ konturdan 1A tok o‘tganda hosil bo‘luvchi magnit oqimi induktivlik deyiladi. Birligi $[L] = \left[\frac{1\ \text{Vb}}{1\ \text{A}}\right] = 1\ \text{H (genri)},\ 1\ \text{mH} = 10^{-3}\ \text{H},\ 1\ \text{mkH} = 10^{-6}\ \text{H}.$

2. O‘zinduksiya hodisasi. Vaqt bo‘yicha o‘zgaruvchan tok g‘altakdan o‘tganda uning atrofida vaqt bo‘yicha o‘zgaruvchan magnit maydon hosil bo‘ladi. Bu magnit maydonning g‘altakda induksion tok hosil qilishiga o‘zinduksiya hodisasi deyiladi.

3. O‘zinduksiya EYK.

$$\mathcal{E}_i = -\frac{\Delta\Phi}{\Delta t} = -L\frac{\Delta I}{\Delta t} \text{ yoki } \mathcal{E}_i = -L\frac{dI}{dt} \text{ yoki}$$

$\mathcal{E}_i = -LI'$, ya’ni $\mathcal{E}_i$ – tokning o‘zgarish tezligi

$\frac{\Delta I}{\Delta t} \approx \frac{dI}{dt}$ ga proporsional. $L = \frac{|\mathcal{E}_i|}{\Delta I/\Delta t}$, birligi

$$[L] = \frac{1\ \text{V}}{1\ \text{A}/1\ \text{s}} = 1\,\frac{\text{V}\cdot\text{s}}{\text{A}} = 1\ \text{H}.\ [L] = 1\ \text{Om}\cdot\text{s}.$$

4. G‘altak (solenoid) induktivligi.

$$\Phi_{um} = N \cdot \Phi = NBS = N\mu\mu_0 \cdot \frac{I \cdot N}{l} \cdot S = \mu\mu_0 n^2 lSI = LI \ ,$$

$$L = \mu\mu_0 \frac{N^2}{l} S = \mu\mu_0 n^2 lS \ ,$$

bu yerda l – solenoid uzunligi, N – o‘ramlar soni, S – o‘ram konturining yuzi, μ – o‘zak (muhit)ning magnit singdiruvchanligi, $n = \frac{N}{l}$ – uzunlik birligidagi o‘ramlar soni, $\mu_0 = 4\pi \cdot 10^{-7} \ \frac{\text{H}}{\text{m}}$.

5. Magnit maydonda bajarilgan ish:

$$A = F_A \cdot x \cdot \cos\beta = IBl \sin\alpha \cdot x \cdot \cos\beta = IB \cdot \Delta S \ ,$$

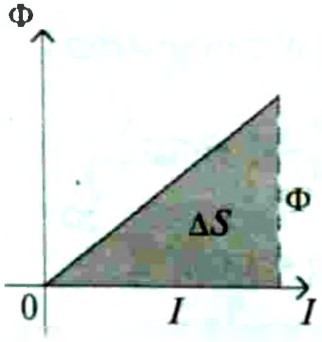
chunki $\alpha = 90^\circ$ va $\beta = 0^\circ$,

$$A = IB \cdot \Delta S = I \cdot \Delta\Phi = I(\Phi_2 - \Phi_1) .$$

6. Induktiv g‘altakdagi magnit maydon energiyasi $W_m = \frac{LI^2}{2}$, bu yerda I – g‘altakdan o‘tayotgan tok kuchi.

$A = W = \frac{I\Phi}{2} = \frac{LI^2}{2}$ (chizmaga qarang).

7. Bir jinsli magnit maydon energiya zichligi:



$$\omega_m = \frac{W_m}{V} = \frac{LI^2}{2V} = \frac{\mu\mu_0 n^2 lSI^2}{2lS} =$$

$$= \frac{1}{2}\mu\mu_0 n^2 I^2 = \frac{1}{2} \cdot \frac{B^2}{\mu\mu_0} ,$$

bu yerda $V = lS$ – solenoid hajmi, $B = \mu\mu_0 In$ – solenoid ichidagi magnit maydon induksiyasi.

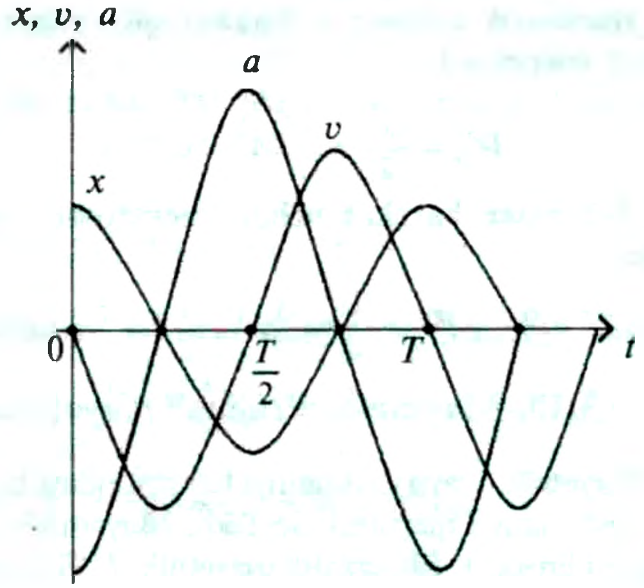
3.17. Mexanik tebranishlar

Vaqt davomida o'zining vaziyatini takrorlab turuvchi harakatga tebranma harakat yoki tebranishlar deyiladi.

1. **Garmonik tebranishlar** – parametrlari sinus yoki kosinus qonunlariga bo'ysunuvchi tebranishlardir. Tebranuvchi jismning muvozanat holatidan siljishi

$$x = x_m \cos(\omega t + \varphi_0) \text{ yoki } x = A\cos(\omega t + \varphi_0),$$

bu yerda ω – tebranishlarning siklik chastotasi bo'lib, $\omega = 2\pi\nu = \frac{2\pi}{T}$ – 2π sekunddagi tebranishlar soni, $\nu = \frac{N}{t}$ – tebranish chastotasi – vaqt birligida tebranishlar soni, N – tebranishlar soni, $T = \frac{t}{N}$ – tebranish davri – bir marta tebranish uchun ketgan vaqt, φ_0 – boshlang'ich fazasi, $\varphi = \omega t + \varphi_0$ – tebranish fazasi, $x_m = A$ – tebranish amplitudasi, ya'ni muvozanat holatidan eng katta siljishi.



2. Garmonik tebranishlarda tezlik.

X o'qi bo'yicha tebranayotgan jismning tezligi

$$\upsilon_x = \upsilon = \frac{\Delta x}{\Delta t} = \frac{dx}{dt} = x'(t) \text{ yoki}$$

$$\upsilon = -A\omega \sin \omega t = A\omega \cos\left(\omega t + \frac{\pi}{2}\right) = \upsilon_m \cos\left(\omega t + \frac{\pi}{2}\right).$$

3. Garmonik tebranishlarda tezlanish:

$a = \dfrac{d\upsilon}{dt} = \upsilon'(t) = -A\omega^2 \cos \omega t = -\omega^2 x$ yoki ($\varphi_0 = 0$ hol uchun) $a = a_m \cos(\omega t + \pi)$ (rasmga qarang).

4. Tezlik amplitudasi: $\upsilon_m = A\omega = A \cdot 2\pi\nu = A\dfrac{2\pi}{T}$.

5. Tezlanish amplitudasi: $a_m = A\omega^2 = A \cdot 4\pi^2\nu^2 = A \cdot \dfrac{4\pi^2}{T^2}$.

6. Garmonik tebranma harakat qilayotgan jismning kinetik energiyasi:

$$W_k = \frac{m\upsilon^2}{2} = \frac{1}{2} mA^2\omega^2 \cdot \sin^2 \omega t,$$

bu yerda m – tebranayotgan jismning massasi.

7. Garmonik tebranma harakat qilayotgan jismning potensial energiyasi:

$$W_p = \frac{kx^2}{2} = \frac{1}{2} kA^2 \cdot \cos^2 \omega t.$$

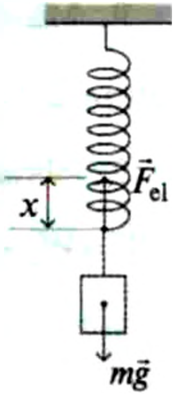
8. Tebranma harakat uchun energiyaning saqlanish qonuni:

$$W = W_k + W_p = \frac{1}{2} mA^2\omega^2 = \frac{1}{2} kA^2 = \text{const}.$$

3.18. Mayatnik. Prujinali mayatnik

1. Mayatnik. Davriy tebranma harakat qiluvchi jism yoki jismlar sistemasiga mayatnik deyiladi. Mayatniklar quyidagi turlarga bo'linadi: 1. Matematik mayatnik. 2. Fizik mayatnik.

2. Nyutonning II qonuniga asosan: $F_t = ma = mx''$ va Guk qonuniga asosan $F_t = F_{el} = -kx$, bundan $ma = -kx$ yoki $x'' + \frac{k}{m}x = 0$ – bu prujinali mayatnikning harakat tenglamasidir. Bu yerda k – prujinaning elastiklik koeffitsiyenti.



Ikkinchi tartibli differensial tenglamaning yechimi sinus yoki kosinus funksiyasi ko'rinishida bo'ladi: $x = A\cos\omega t$ ($\varphi_0 = 0$ uchun).

3. Prujinali mayatnikning siklik chastotasi:

$$a = \frac{F_{el}}{m} = -\frac{k}{m}x \text{ va } a = -\omega^2 x \text{ uchun } \omega^2 = \frac{k}{m},\ \omega = \sqrt{\frac{k}{m}}.$$

4. **Tebranish chastotasi:** $\nu = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$.

5. Tebranish davri: $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$, $T \sim \sqrt{m}$, $T \sim \frac{1}{\sqrt{k}}$.

6. Tebranma harakat qilayotgan jismning kinetik energiyasi:

$$W_k = \frac{mv^2}{2} = \frac{1}{2}m(x')^2 = \frac{1}{2}mA^2\omega^2\sin^2\omega t.$$

7. Tebranma harakat qilayotgan jismning potensial energiyasi $W_p = \frac{kx^2}{2} = \frac{1}{2}kA^2\cos^2\omega t$ yoki $k = \omega^2 m$ bo'lgani uchun $W_p = \frac{kx^2}{2} = \frac{1}{2}mA^2\omega^2\cos^2\omega t$.

8. Muvozanat holatida yoki muvozanatdan maksimal og'ganda $W_{k\,max} = W_{p\,max} = \frac{mv_{max}^2}{2} = \frac{kx_{max}^2}{2}$.

9. Tebranma harakat qilayotgan jismning to'la energiyasi:

$$W = W_k + W_p = \frac{1}{2}mA^2\omega^2 \sin^2 \omega t + \frac{1}{2}mA^2\omega^2 \cos^2 \omega t =$$
$$= \frac{1}{2}mA^2\omega^2 = \text{const}.$$

3.19. Matematik mayatnik

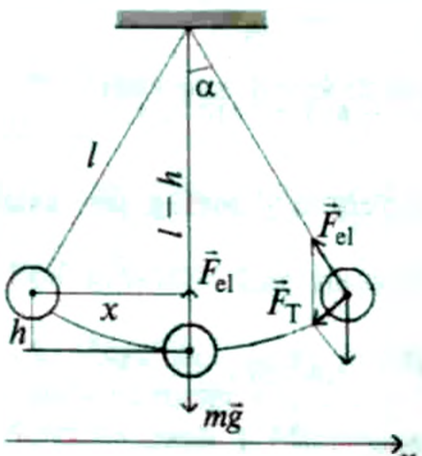
1. Vaznsiz, cho'zilmaydigan ipga osilgan sharchadan tashkil topgan va muvozanat vaziyati atrofida davriy tebranma harakat qiluvchi sistemaga **matematik mayatnik** deyiladi. Matematik mayatnik ichki kuch — og'irlik kuchining tashkil etuvchisi ta'sirida tebranadi.

2. Mayatnikni harakatga keltiruvchi kuch:

$$F_T = -mg \sin\alpha,$$

α kichik ($\alpha \leq 10-12°$) bo'lganda, $\sin\alpha \approx \alpha \approx \frac{x}{l}$ va

$F_T = -mg\frac{x}{l}$. $F_T \sim x$. (−) ishorasi $\vec{F} \uparrow\downarrow x$ ekanligini ko'rsatadi.



Nyutonning II qonuniga asosan:

$$ma = mx'' = F_T = -mg\frac{x}{l}.$$

$x'' + \frac{g}{l}x = 0$ — mayatnikning harakat tenglamasi.

Bu tenglamaning yechimi sinus yoki kosinus funksiyasi ko'rinishda bo'ladi: $x = A\cos\omega t$ ($\varphi_0 = 0$ uchun).

3. Matematik mayatnikning siklik chastotasi:

$$a = \frac{F_T}{m} = -\frac{g}{l}x \text{ va } a = -\omega^2 x \text{ dan } \omega^2 = \frac{g}{l},\ \omega = \sqrt{\frac{g}{l}} \text{ –}$$

matematik mayatnikning siklik chastotasi.

4. Tebranish chastotasi: $\nu = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$.

5. Tebranish davri: $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{l}{g}}$.

6. Matematik mayatnik qonunlari:

a) tebranish davri m ga bog'liq emas ($T \sim m$);

b) α kichik ($\alpha \leq 10-12°$) bo'lganda, tebranish davri A ga (α ga) bog'liq emas ($T \sim m$);

d) tebranish davri $T \sim \sqrt{l}$ va $T \sim \frac{1}{\sqrt{g}}$.

7. Kinetik energiyasi:

$$W_k = \frac{mv^2}{2} = \frac{1}{2}m(x')^2 = \frac{1}{2}mA^2\omega^2 \sin^2 \omega t .$$

8. Potensial energiyasi: $W_p = mgh$.

Chizmadan $h = l(1 - \cos\alpha) = l \cdot 2 \cdot \sin^2 \frac{\alpha}{2}$. α kichik bo'lganda, $\sin^2 \frac{\alpha}{2} \approx \left(\frac{\alpha}{2}\right)^2 \approx \frac{1}{4} \cdot \frac{x^2}{l^2}$ bo'lgani uchun:

$$W_p = mgh = \frac{1}{2}m\frac{g}{l}x^2 = \frac{1}{2}m\omega^2 \cdot A^2 \cos^2 \omega t .$$

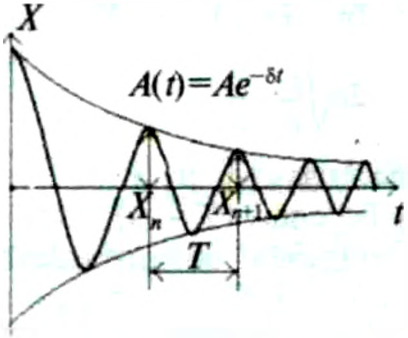
9. Energiya saqlanishi qonuni:

$$W = W_k + W_p = \frac{1}{2}mA^2\omega^2 \sin^2 \omega t + \frac{1}{2}mA^2\omega^2 \cos^2 \omega t =$$

$$= \frac{1}{2}mA^2\omega^2 = \text{const}.$$

3.20. So'nuvchi va majburiy tebranishlar

1. Tebranishlar: 1) erkin xususiy tebranishlar (ichki kuchlar ta'siridagi tebranishlar); 2) majburiy tebranishlar (davriy tashqi kuch ta'sirida); 3) avtotebranishlar (ichki manba energiyasi hisobiga).



2. So'nuvchan tebranishlar (tabiatda barcha tebranishlar ishqalanish va qarshilik kuchlari mavjud bo'lgani uchun so'nuvchan bo'ladi):

$$x = e^{-\delta \cdot t} A_0 \cdot \cos(\omega t + \varphi_0),$$

bu yerda δ – so'nish koeffitsiyenti.

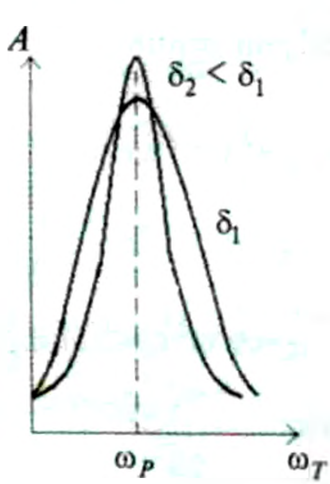
3. So'nishning logarifmik dekrementi:

$$\theta = \ln\frac{x_n}{x_{n+1}} = \ln\frac{A_0 \cdot e^{-\delta \cdot t}\cos(\omega t + \varphi_0)}{A_0 \cdot e^{-\delta(t+T)} \cdot \cos\left[\omega(t+T)+\varphi_0\right]} = \ln e^{\delta \cdot T} = \delta \cdot T .$$

Bu yerda $T = 2\pi / \sqrt{\omega_0^2 - \delta^2}$

4. So'nuvchi tebranishlarda energiyaning o'zgarishi:

$$W(t) = W_0 \cdot e^{-2\delta \cdot t},$$



W_0 – energiyaning boshlang'ich qiymati.

5. Tashqi davriy $F = F_0 \cos \omega_T t$ kuch ta'sirida ro'y beradigan tebranishlarga majburiy tebranishlar deyiladi.

Tebranish amplitudasi:

$$A = \frac{F_0}{m\sqrt{\left(\omega^2 - \omega_T^2\right) + 4\delta^2\omega_T^2}},$$

bu yerda m – tebranuvchi jism

yoki sistemaning massasi; ω_T – tashqi kuch siklik chastotasi.

6. Rezonans hodisasi – tashqi kuch tebranishlarining chastotasi ω_t sistemaning xususiy tebranish chastotasi ω_t, ω ga teng bo'lganda tebranish amplitudasining keskin oshib maksimal qiymatga ega bo'lishidir. U holda $\omega = \omega_t = \omega_r$ – rezonans chastotasi bo'lganda $A = A_{max} = \dfrac{F_0}{m \cdot 2\delta\omega_T}$ ga teng bo'ladi. Agar $\delta \to 0$, $A_{rez} \to \infty$.

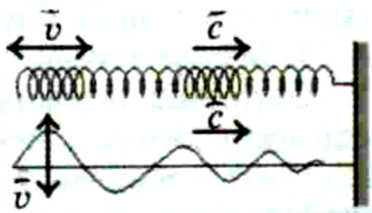
Tebranish amplitudasi A ning tashqi kuch chastotasi ga bog'liqlik egri chizig'iga rezonans egri chizig'i deyiladi.

7. Avtotebranishlar – tashqi o'zgaruvchan kuch ta'siri bo'lmaganda ichki energiya manbalari hisobiga bo'ladigan so'nmas tebranuvchi sistemalar tebranishidir.

Avtotebranish sistemasi elementlari →
- tebranish sistemasi;
- energiya manbayi;
- manbadan tebranish sistemasiga energiya kelishini rostlovchi teskari bog'lanishli qurilma

3.21. Mexanik to'lqinlar. Tovush

1. To'lqin. Tebranishlarning elastik muhitda vaqt bo'yicha tarqalish jarayoniga mexanik to'lqin deyiladi.



To'lqinlar: 1) bo'ylama; 2) ko'ndalang bo'ladi.

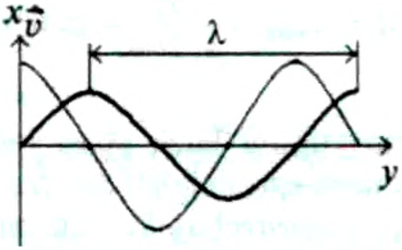
Agar tebranish yo'nalishi to'lqin yo'nalishi bilan bir o'qda bo'lsa, bunday to'lqin *bo'ylama to'lqin*, agar tebranish yo'nalishi to'lqin tarqalish yo'nalishiga perpendikular bo'lsa, *ko'ndalang to'lqin* deyiladi.

2. To‘lqin tenglamasi:

$$x = A\sin\omega\left(t - \frac{y}{c}\right) = A\sin 2\pi\left(\frac{t}{\tau} - \frac{y}{\lambda}\right).$$

To‘lqin tebranish tezligi:

$$x' = v = \omega A\cos\omega\left(t - \frac{y}{c}\right) = -\,\omega A\cos 2\pi\left(\frac{t}{\tau} - \frac{y}{\lambda}\right),$$



bu yerda c — to‘lqinning tarqalish tezligi; $\lambda = c \cdot T$, $\lambda = \frac{c}{\nu}$ — to‘lqin uzunligi; T — tebranish davri; ν — chastotasi.

Ikkita bir xil fazoda tebranayotgan eng yaqin nuqtalar orasidagi masofa yoki bir to‘la tebranish vaqtida to‘lqinning bosib o‘tgan masofasi **to‘lqin uzunligi** deyiladi.

3. Tovush — chastotasi 17 Hz dan 20 000 Hz gacha bo‘lgan bo‘ylama mexanik to‘lqin.

Tovushlar turi: infratovush (ν < 17 Hz), eshitiluvchi tovush, ultratovush (ν > 20 kHz).

4. Tovush xususiyati va xossalari:

a) tovush tezligi (muhit zichligiga, temperaturaga bog‘liq);

b) tovush kuchi;

d) tovush balandligi (yuksakligi);

e) tovush tembri — tovush tebranishlarining spektral tarkibi — tebranish sofligini tavsiflaydi.

5. Musiqa tovushi. Shovqin.

Garmonik tebranma harakat qilayotgan jismning chiqargan tovushi musiqa toni deyiladi.

Har bir musiqa toni (do, re, mi, fa, sol, lya, si)ga ma’lum tovush to‘lqin uzunligi va chastotasi mos keladi.

Shovqin — tartibsiz tonlarning majmuasidir.

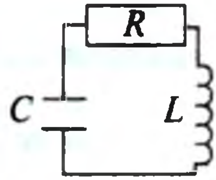
6. Fizikaning tovush hodisalarini o‘rganuvchi bo‘limi **akustika** deyiladi.

7. Ultra tovushlar texnikada va meditsinada keng qo‘llaniladi.

3.22. Elektromagnit tebranishlar

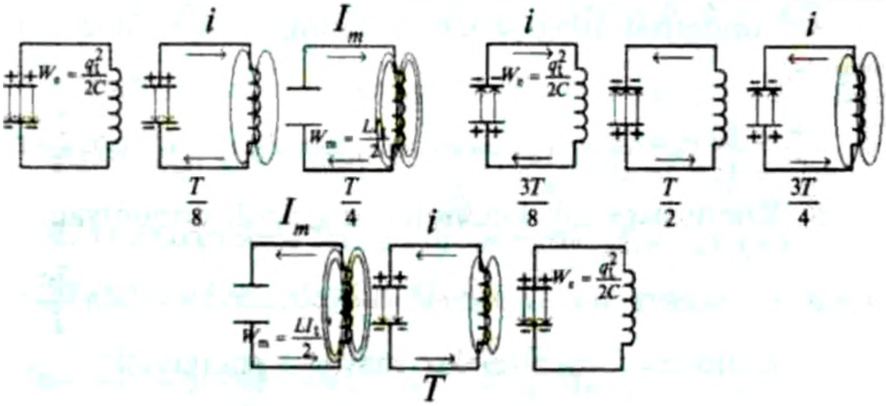
Zaryad, tok kuchi va kuchlanishlarning vaqt davomida davriy ravishda o'zgarishiga **elektr tebranishlari** deyiladi.

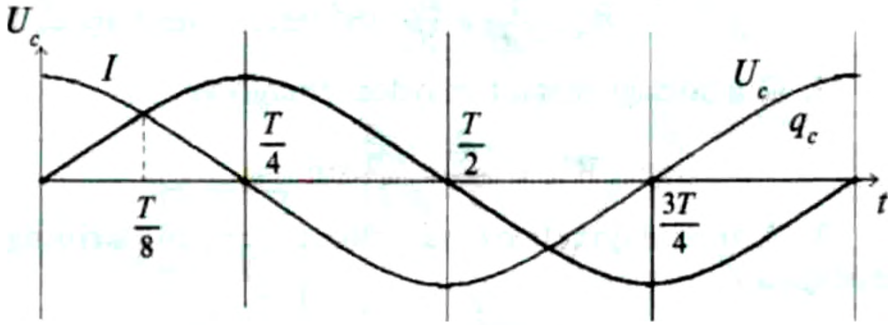
1. Tebranish konturi: L – induktiv g'altak va C – kondensatordan tashkil topgan berk zanjir.



Ideal tebranish konturi uchun $R = 0$.

2. Elektr konturida tebranishlar.





3. Erkin tebranishlar davri.

Kondensator qoplamalaridagi kuchlanish U_C va g'altak uchlaridagi kuchlanish U_L teng va qarama-qarshi ishorada

$U_C = -U_L$ va $U_C = \frac{q}{C}$ bo'lgani uchun $\frac{q}{C} = -Lq''$,

$U_L = |\mathscr{E}_i| = L\frac{\Delta i}{\Delta t} = L \cdot i' = L \cdot q''$, $q'' + \frac{1}{LC}q = 0$.

Bu tenglamani yechimi kosinus yoki sinus funksiyasi ko'rinishida bo'ladi: $q = q_0 \cos \omega t$.

Bunda siklik chastota: $\omega = \sqrt{\frac{1}{LC}}$.

Tebranish chastotasi: $\nu = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$.

Tebranish davri (Tomson formulasi): $T = \frac{2\pi}{\omega} = 2\pi\sqrt{LC}$.

4. Kondensatordagi kuchlanishning o'zgarish qonuniyati:

$$U = \frac{q}{C} = \frac{q_0}{C}\cos \omega t = U_0 \cos \omega t = U_0 \cos 2\pi\nu t = U_0 \cos \frac{2\pi}{T} t .$$

5. Konturdagi tok kuchining o'zgarish qonuniyati:

$$i = q' = -q_0\omega \sin \omega t = -i_0 \sin \omega t = -i_0 \sin 2\pi\nu t = -i \sin \frac{2\pi}{T} t .$$

6. Kondensatordagi elektr maydon energiyasi:

$$W_e = \frac{q^2}{2C} = \frac{q_0^2}{2C}\cos^2 \omega t .$$

7. G'altakdagi magnit maydon energiyasi:

$$W_m = \frac{Li^2}{2} = \frac{Li_0^2}{2}\sin^2 \omega t .$$

8. Konturdagi elektr va magnit maydonlarining energiyasi:

$$W = W_e + W_m = \frac{q^2}{2C} + \frac{Li^2}{2} = \frac{q_0^2}{2C} = \frac{Li_0^2}{2} = \text{const} ,$$

chunki $W_{emax} = W_{max}$ yoki $\frac{q_0^2}{2C} = \frac{Li_0^2}{2}$.

3.23. O'zgaruvchan elektr toki

1. O'zgaruvchan tok – vaqt davomida kattaligi va yo'nalishi davriy ravishda o'zgarib turuvchi tokdir.

2. O'zgaruvchan tok generator yordamida hosil qilinadi. Mexanik energiyani elektr energiyasiga aylantirib beruvchi qurilmaga generator deyiladi.

3. O'zgaruvchan tok elektromagnit induksiya hodisasi asosida hosil qilinadi. O'ram yuzasini kesib o'tuvchi Φ oqim $\Phi = B \cdot S_N$, $\Phi = B \cdot S \cdot \cos\alpha$, burilish burchagi $\alpha = \omega t = 2\pi\nu t$, $\Phi = B \cdot S \cdot \cos\omega t = B \cdot S \cdot \cos 2\pi\nu t$.

Induksion EYK: $\mathcal{E} = -\frac{\Delta\Phi}{\Delta t} = -\frac{d\Phi}{dt} = -\Phi' = B \cdot S \cdot \omega \cdot \sin\omega t$.

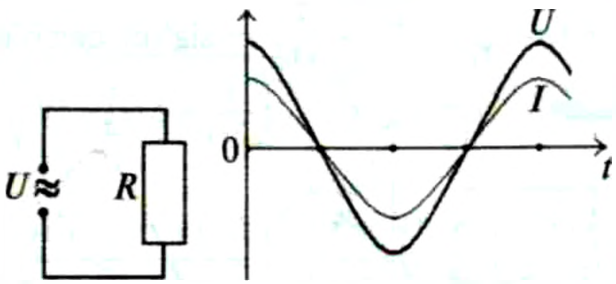
O'ramlar soni N ta bo'lganda $\mathcal{E} = -N \cdot B \cdot S \cdot \omega \sin\omega t$.

Zanjirdagi tok kuchi: $i = \frac{\mathcal{E}}{R} = \frac{BS\omega}{R} \sin\omega t = i_0 \sin\omega t$.

4. O'zgaruvchan tok zanjirida aktiv qarshilik (*R*).

Manbadagi kuchlanish $U = U_0 \sin\omega t$ qonuniyat bilan o'zgarsa, zanjirdagi tok kuchi $i = \frac{U_0}{R} \sin\omega t$, $i = i_0 \sin\omega t$.

R da ajralgan quvvat: $P = iU = i_0 U_0 \sin^2\omega t = \frac{1}{2} i_0 U_0$.



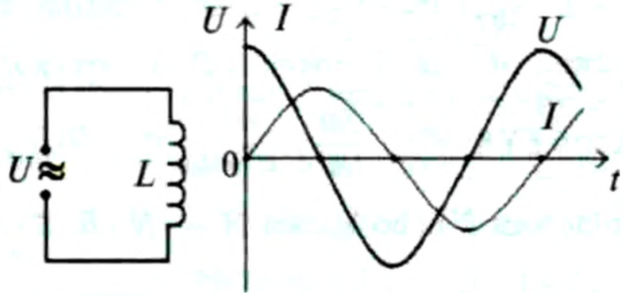
5. O'zgaruvchan tok va kuchlanishning effektiv (amaliy) qiymatlari: $i_{ef} = \frac{i_0}{\sqrt{2}}$, $U_{ef} = \frac{U_0}{\sqrt{2}}$.

6. O'zgaruvchan tok zanjirida induktivlik.

$U = \mathcal{E}_i$ va $i = i_0 \sin\omega t$ bo'lsa,

$U = -\mathcal{E}_i = Li' = L \cdot i_0 \cdot \omega \cos\omega t = L \cdot \omega \cdot i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$.

Kuchlanish tebranishlari g'altakda tok tebranishlaridan $\frac{\pi}{2}$ ga o'zib ketadi. $U_0 = i_0 \cdot L\omega = i_0 X_L$, $X_L = \omega \cdot L$ – induktiv qarshilik. $i = \frac{U}{X_L} = \frac{U}{\omega L}$, $i_0 = \frac{U_0}{X_L} = \frac{U_0}{\omega L}$.

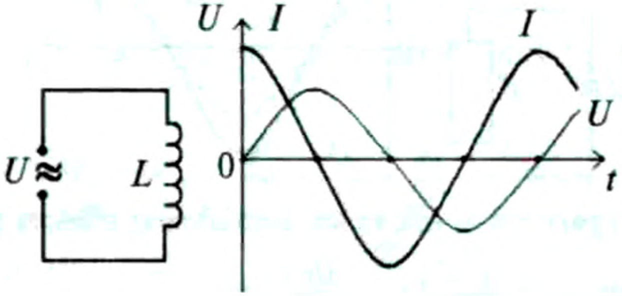


7. O'zgaruvchan tok zanjirida sig'im.

$U = U_0 \sin \omega t$ bo'lsa, $q = CU = U_0 C \sin \omega t$.

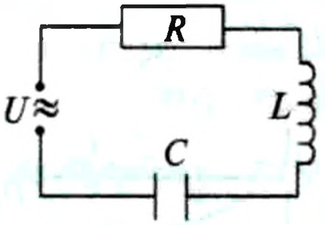
$i = \frac{\Delta q}{\Delta t} = q' = U_0 \cdot C \cdot \omega \cdot \cos \omega t = U_0 \cdot C \cdot \omega \cdot \sin\left(\omega t - \frac{\pi}{2}\right)$ – tok kuchi tebranishlari kondensatorda kuchlanish tebranishlaridan $\frac{\pi}{2}$ ga o'zib ketadi.

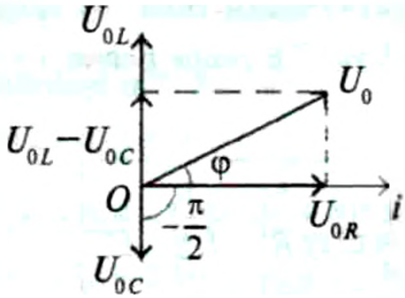
$i_0 = U_0 \omega C = \frac{U_0}{X_C}$, $X_C = \frac{1}{\omega C}$ – sig'im qarshilik.



3.24. O'zgaruvchan tok uchun Om qonuni

1. O'zgaruvchan tok zanjiriga ketma-ket ulangan *R*, *L* va *C* li zanjir uchun: $U = U_R + U_L + U_C$.





a) har bir element uchun kuchlanishlar:

$$U_R = i_0 R \sin \omega t \text{ , } i = i_0 \sin \omega t,$$

$$U_L = i_0 L\omega \sin\left(\omega t + \frac{\pi}{2}\right) = U_{0L} \sin\left(\omega t + \frac{\pi}{2}\right),$$

$$U_C = i_0 \cdot \frac{1}{\omega C} \sin\left(\omega t - \frac{\pi}{2}\right) = U_{0C} \sin\left(\omega t - \frac{\pi}{2}\right);$$

b) natijaviy kuchlanish amplitudasi U_0 vektor diagrammaga asosan:

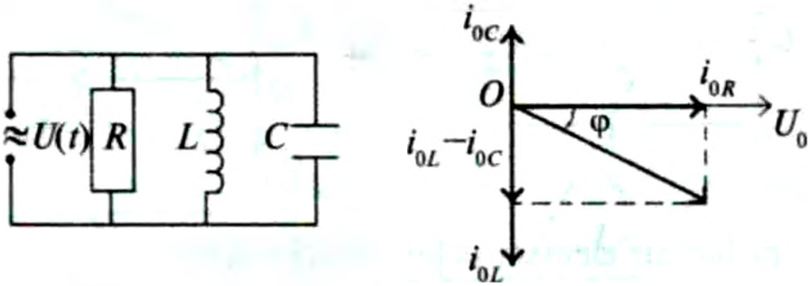
$$U_0 = \sqrt{U_{0R}^2 + (U_{0L} - U_{0C})^2} = i_0 \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = i_0 \cdot Z.$$

$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$ – zanjirning impedansi (to‘la qarshiligi).

d) Zanjirda kuchlanish $U = U_0 \sin \omega t$ va tok $i = i_0 \sin(\omega t + \varphi)$ qonuniyat bilan o‘zgaradi va chizmadan fazalar farqi $\mathrm{tg}\varphi = \frac{U_{0L} - U_{0C}}{U_{0R}}$ yoki $\mathrm{tg}\varphi = \frac{\omega L - \frac{1}{\omega C}}{R}$ dan aniqlanadi.

e) Bu hol uchun Om qonuni $i_0 = \frac{U_0}{Z}$ yoki $i = \frac{U}{Z}$.

2. O‘zgaruvchan tok zanjiriga o‘zaro parallel ulangan R, L va C li zanjir uchun $i = i_R + i_L + i_C$.



a) manbadagi kuchlanish $U = U_0 \sin \omega t$ bo‘lsa, zanjirdagi umumiy tok $i = i_0 \sin(\omega t + \varphi)$ bo‘ladi:

b) zanjir tarmoqlaridagi toklarning oniy qiymatlari

$$i_R = \frac{U_0}{R} \sin \omega t, \quad i_L = \frac{U_0}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right), \quad i_C = U_0 \omega C \sin\left(\omega t + \frac{\pi}{2}\right);$$

d) vektor diagrammadan:

$$i_0 = \sqrt{i_{0R}^2 + (i_{0L} - i_{0C})^2}; \qquad i_0 = U_0 \sqrt{\frac{1}{R^2} + \left(\frac{1}{\omega L} - \omega C\right)^2};$$

$i_0 = \frac{U_0}{Z}$ va $\frac{1}{Z} = \sqrt{\frac{1}{R^2} + \left(\frac{1}{\omega L} - \omega C\right)^2}$ fazaning o‘zgarishi

$$\operatorname{tg}\varphi = R\left(\frac{1}{\omega L} - \omega C\right).$$

3. a) o‘zaro ketma-ket ulangan zanjirda kuchlanish rezonansi uchun: $\omega_0^2 = \frac{1}{LC} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$;

b) o‘zaro parallel ulangan zanjirda tok rezonansi uchun $\frac{1}{\omega_0 L} - \omega_0 C = 0$ bo‘lishi kerak. $\omega_0^2 = \frac{1}{LC} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$.

3.25. O‘zgaruvchan tok quvvati. Transformator

1. O‘zgaruvchan tok zanjirdagi oniy quvvat.

$$P(t) = iU = U_0 \sin \omega t \cdot i_0 \sin(\omega t + \varphi)$$

soddalashtirsak, $P(t) = \frac{1}{2} U_0 i_0 \left[\cos\varphi - \cos(2\omega t + \varphi)\right]$.

$t \geq T$ vaqt uchun $\cos(2\omega t + \varphi) = 0$ (yig‘indi qiymati)

va $P(t) = \frac{1}{2} U_0 i_0 \cos\varphi$ yoki $P = U_{ef} i_{ef} \cdot \cos\varphi$, chunki

$U_{ef} = \frac{U_0}{\sqrt{2}}$ va $i_{ef} = \frac{i_0}{\sqrt{2}}$.

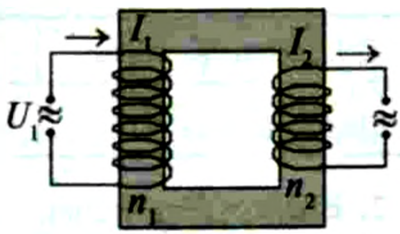
O‘zgaruvchan tokning effektiv qiymati shunday kattalikki, uning ta’siri (quvvati, energiyasi) shu kattalikdagi o‘zgarmas tokning ta’siri bilan bir xildir.

2. O‘zgaruvchan tokning ishi: $A = P \cdot t = \frac{1}{2} U_0 i_0 \cos\varphi \cdot t$, bu yerda $\cos\varphi$ — quvvat koeffitsiyenti.

3. Transformator. (P.N. Yablochkov, 1878-y.).

Belgilanishi 

Ferromagnit o‘zak va unga o‘ralgan sim g‘altaklardan tashkil topgan hamda o‘zgaruvchan tokning kuchlanishini (tok kuchini) o‘zgartirib beruvchi qurilmaga **transformator** deyiladi.



a) ferromagnit o‘zakdagi birlamchi g‘altakdagi (chulg‘amdan) tok o‘tgandagi hosil bo‘lgan oqim: $\Phi = \Phi_0 \cos\omega t$.

b) bitta o‘ramdan hosil bo‘lgan o‘zinduksiya:

$$\mathscr{E} = -\frac{\Delta\Phi}{\Delta t}, = -\Phi' = -\Phi_0 \omega \sin\omega t;$$

d) birlamchi chulg'amdagi induksion EYK:

$$\mathscr{E}_1 = \mathscr{E} \cdot n_1 = -n_1\Phi_0\omega \sin \omega t ;$$

e) ikkilamchi chulg'amdagi induksion EYK:

$$\mathscr{E}_2 = \mathscr{E} \cdot n_2 = -n_2\Phi_0\omega \sin \omega t ;$$

f) nagruzka (yuklanish) bo'lmaganda $U_1 = \mathscr{E}_1$ va $U_2 = -\mathscr{E}_2$, shuning uchun $\frac{\mathscr{E}_1}{\mathscr{E}_2} = \frac{U_1}{U_2} = \frac{n_1}{n_2} = k$, $k = \frac{n_1}{n_2}$, transformatsiya koeffitsiyenti.

$k > 1$ — pasaytiruvchi, $k < 1$ — kuchaytiruvchi (oshiruvchi) transformatorlardir;

g) agar transformatorlarda energiyaning yo'qolishini hisobga olmasak (amalda FIK 98—99,5 %), $\frac{1}{2}U_1 i_1 \cdot \cos\varphi_1 = \frac{1}{2}U_2 i_2 \cos\varphi_2$ yoki $U_1 i_1 = U_2 i_2$ ga binoan $k = \frac{U_1}{U_2} = \frac{i_2}{i_1}$.

3.26. Elektr energiyani ishlab chiqarish va uzatish

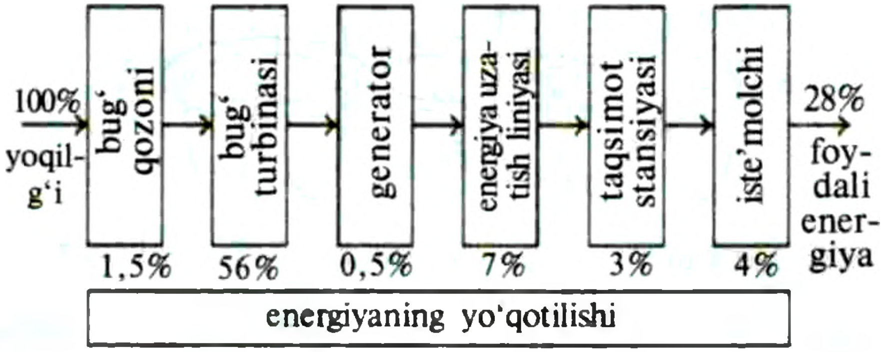
1. Elektr energiyani ishlab chiqarish.

Elektrostansiya turlari	IES	IEM	GES	AES
Elektrostansiya FIK	40%	70%	95%	20%

2. Elektroenergiyaning taqsimoti.

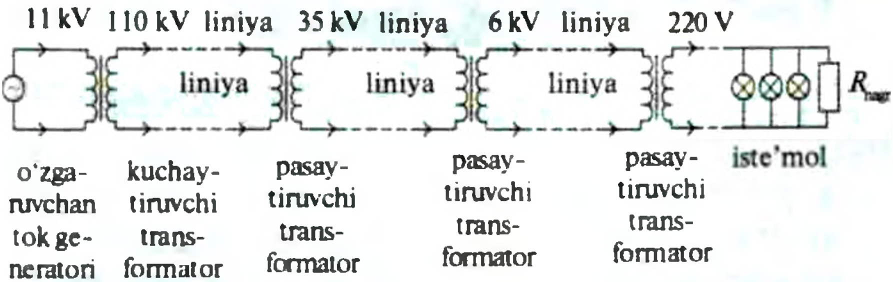
Xo'jalik tarmoqlari:
- Ishlab chiqarish korxonalari — 70%.
- Transport — 15%.
- Qishloq xo'jaligi — 10%.
- Turmushda — 4%.

3. Elektroenergiyaning iste'molchiga uzatilishda energiya yo'qolishlari.



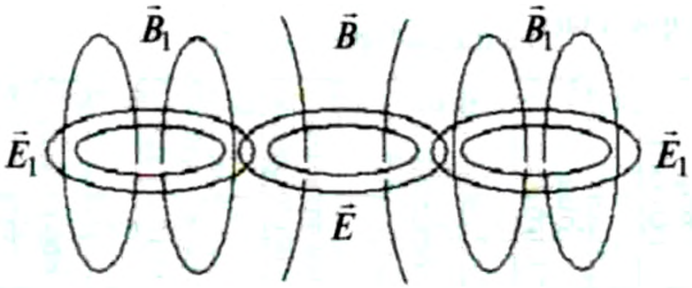
4. Elektroenergiyani uzatishida energiyaning issiqlikka aylanib ($Q = I^2Rt$) yo'qolishini kamaytirish uchun liniya qarshiligini ($R = \rho\frac{l}{S}$) kamaytirish, ya'ni S – simning ko'ndalang kesim yuzasini oshirish iqtisodiy va texnik noqulay. Shuning uchun quvvat ($P = I \cdot U$) doimiy qoldirilib, tok kuchi kamaytirilib, kuchlanishi oshiriladi ($U = 6$ kV÷110 kV).

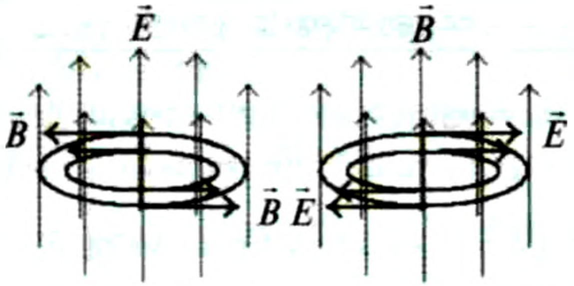
Elektroenergiya uzatilishi va taqsimot sxemasi.



3.27. Elektromagnit to'lqinlar

1.O'zgaruvchan elektr maydon ⇒ o'zgaruvchan magnit maydon, o'zgaruvchan magnit maydoni ⇒ o'zgaruvchan uyurmaviy elektr maydonni hosil qiladi.





$\frac{\Delta E}{\Delta t} > 0$ $\qquad$ $\frac{\Delta B}{\Delta t} < 0$

2. Elektromagnit tebranishlarning fazoda vaqt bo'yicha tarqalishi – elektromagnit to'lqindir (EMT).

3. EMT ning vakuumdagi tarqalish tezligi $c = 3\cdot10^8$ m/s, muhitdagi tezligi $\upsilon = \frac{c}{n}$, $n = \sqrt{\varepsilon\mu}$ – muhitning sindirish ko'rsatkichi.

4. EMT xossalari:

a) EMT ko'ndalang to'lqin, ya'ni $\vec{E} \perp \vec{B} \perp \vec{c}$;

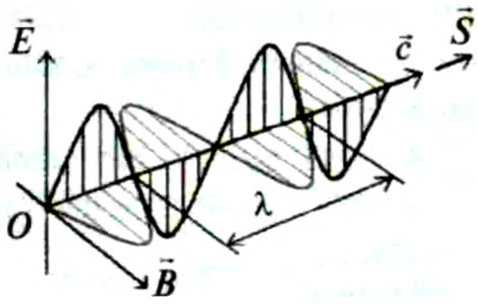
b) EMT to'lqinlar kabi qaytish va sinish qonunlariga bo'ysunadi;

d) kogerent manbadan tarqalayotgan EMT uchrashib **interferensiya** hosil qiladi ($\omega_1 = \omega_2$, $\Delta\varphi = $ const);

e) EMT larda **difraksiya** hodisasi kuzatiladi;

f) EMT lar qutblanadi.

5. EMT energiyasi.



Yuza birligidan vaqt birligida oqib o‘tuvchi EMT energiyasi $P = \dfrac{\Delta W}{\Delta S \cdot \Delta t} = EB$ yoki $\vec{P} = [\vec{E} \cdot \vec{B}]$ – Umov-Poynting vektori $\vec{c}$ bo‘yicha yo‘nalgan.

6. EMT nurlanish oqimi $\Phi = \dfrac{\Delta W}{\Delta t}$.

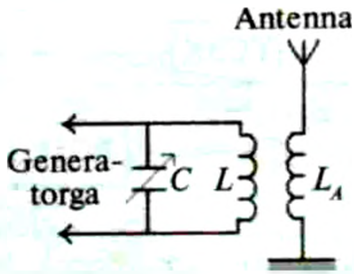
7. EMT nurlanish oqimining sirtiy zichligi $P = \dfrac{\Phi}{S}$ yoki $P = \dfrac{\Delta W}{\Delta S \cdot \Delta t}$.

8. EMT ochiq tebranish konturi **antenna** yordamida tarqatiladi va qabul qilinadi.

3.28. Elektromagnit to‘lqin (EMT) nurlanishi va radioaloqa prinsipi

1. **Elektromagnit to‘lqin manbayi** – tezlanish bilan harakatlanayotgan zaryadli zarracha yoki vaqt bo‘yicha o‘zgaruvchi elektr tokidir (maydondir).

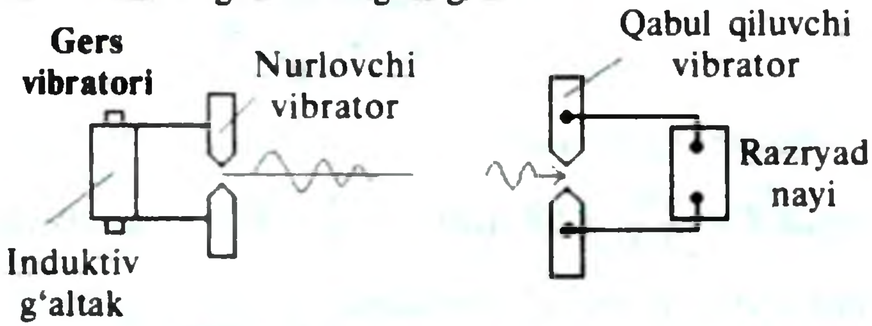
2. **EMT nurlanish quvvati** – chastotaning to‘rtinchi darajasiga proporsional, ya’ni $P \sim \omega^4$ yoki $\sim \nu^4$.



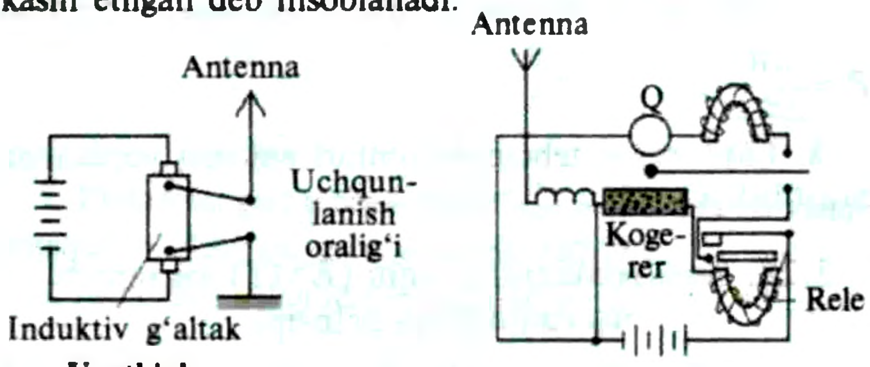
3. EMT har qanday o‘tkazgichdan o‘zgaruvchan elektr toki o‘tganda undan tarqaladi.

Effektiv nurlanish – ochiq tebranish konturi antenna orqali amalga oshiriladi. Qabul qilish ham shunday holda effektivdir.

4. EMT birinchi bor Genrix Gers tomonidan 1687-yilda kashf etilgan va o‘rganilgan.



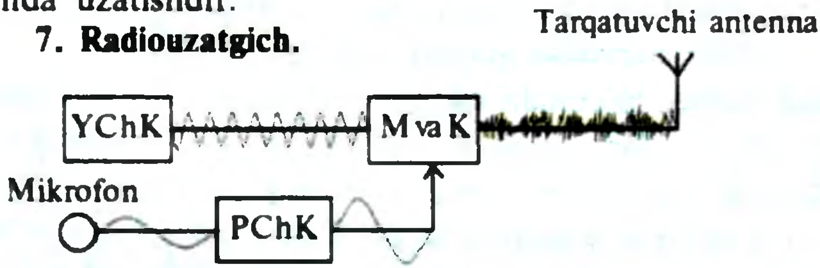
5. Radio italiyalik Merkoni tomonidan yaratilgan va A.S. Popov tomonidan takomillashtirilib 1895- yil 5-mayda kashf etilgan deb hisoblanadi.



Uzatkich **Qabul qilgich**

6. Radioaloqa – bu ma'lumotni radioto‘lqin yordamida uzatishdir.

7. Radiouzatgich.



YChK – yuqori chastotali kuchaytirgich; PChK – past chastotali kuchaytirgich; M va K – modulator va kuchaytirgich.

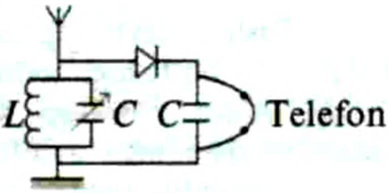
8. Radiopriyomnik.

9. Past chastotali tovush to‘lqini bo‘yicha yuqori chastotali eltuvchi signalni amplitudasining o‘zgarishga **amplitudaviy modulatsiya** deyiladi.

10. Amplitudaviy modulatsiyalangan yuqori chastotali signaldan past chastotali tovush tebranishlarini ajratish jarayoniga **detektorlash** deyiladi.

11. Detektorli priyomnik.

≠ – o‘zgaruvchan sig‘imli kondensator



12. Radioto‘lqin turlari.

Radioto‘lqin:
- juda uzun, $\lambda > 10^5$ m, $\nu < 3 \cdot 10^4$ Hz
- uzun, $\lambda > 10^3 \div 10^5$ m, $\nu < 3 \cdot 10^4 \div 3 \cdot 10^5$ Hz
- o‘rta, $\lambda > 10^2 \div 10^3$ m, $\nu < 3 \cdot 10^5 \div 3 \cdot 10^6$ Hz
- qisqa, $\lambda = 100 \div 10$ m, $\nu = 3 \cdot 10^6 \div 3 \cdot 10^7$ Hz
- ultraqisqa to‘lqinlar

metrli	detsimetrli	santimetrli	millimetrli
$\lambda = 10 \div 1$ m, $\nu = 3 \cdot 10^7 \div 3 \cdot 10^8$ Hz	$\lambda = 1 \div 0,1$ m, $\nu = 3 \cdot 10^8 \div 3 \cdot 10^9$ Hz	$\lambda = 0,1 \div 0,01$ m, $\nu = 3 \cdot 10^9 \div 3 \cdot 10^{10}$ Hz	$\lambda = 0,01 \div 0,001$ m, $\nu = 3 \cdot 10^{10} \div 3 \cdot 10^{11}$ Hz

13. Radiolokatsiya – bu radioto'lqinlar yordamida obyekt vaziyatini aniqlashdir ($\nu = 10^8 \div 10^4$ Hz, $\lambda \leq 0,1$ m).

14. Radiolokator (radar) – bu radionur hosil qilib, ultraqisqa to'lqinda – radiotarqatish va radioto'lqinlarni qabul qilishdir.

Nurlanish qisqa impulslarda amalga oshiriladi ($\Delta t \approx 10^{-6}$ s).

15. Nishonning uzoqligi $S = \frac{c \cdot \Delta t}{2}$ ifoda orqali aniqlanadi. Bu yerda Δt – uzatilgan va nishondan qaytgan impulslar orasidagi vaqt.

3.29. So'nmaydigan tebranishlarning avtotebranish generatori

1. Tashqi davriy ta'sirsiz so'nmaydigan tebranishlarning hosil bo'lishiga **avtotebranishlar** deyiladi.

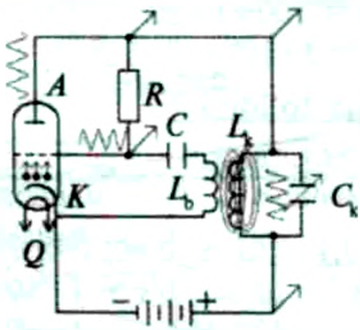
2. Manba hisobiga so'nmaydigan tebranishlar hosil qiluvchi sistemaga avtotebranishlar generatori deyiladi.

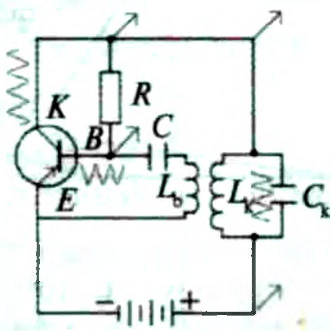
3. Avtotebranishlar sistemasining funksional tuzilishi.

Teskari bog'lanish

Energiya manbayi → Energiyaning kelishini boshqaruvchi qurilma → Tebranish hosil qiluvchi sistema

4. **Lampali generator** **Tranzistorli generator**





4.1. Fotometriya asoslari (yorug'likning energetik xarakteristikalari)

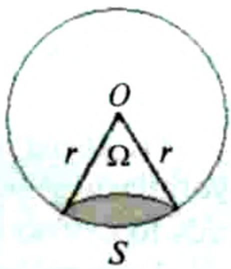
1. **Nurlanish energiyasi** – bu fotonlar energiyasi yoki elektromagnit to'lqin energiyasidir.

2. **Nurlanish yoki yorug'lik oqimi** – bu biror yuzadan vaqt birligida oqib o'tuvchi yorug'lik energiyasi, ya'ni $\Phi = \frac{\Delta W}{\Delta t}$, birligi $[\Phi] = 1$ lm (lyumen) $= \frac{1\ \text{J}}{1\ \text{s}}$. Demak, yorug'lik oqimi – bu yorug'lik nurlanish quvvatidir.

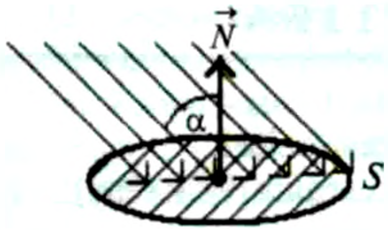
3. Yorug'lik nurlanish energiyasi yoki oqimi **fotoelementlar, bolometr** yordamida o'lchanadi.

4. Barcha yo'nalishda yorug'likni bir xil tarqatib, o'lchamlari ko'rilayotgan masofa va o'lchamlarga nisbatan juda kichik bo'lgan yorug'lik manbayi **nuqtaviy yorug'lik manbayi** deyiladi.

5. **Yorug'lik tarqalishi fazoviy burchak Ω bilan xarakterlanadi.** Fazoviy burchak – konik sirt bilan chegaralangan soha bo'lib, fazoviy burchak bilan chegaralangan shar segmenti yuzasini radius kvadrati nisbatiga teng: $\Omega = \frac{S}{r^2}$. Birligi – steradian (sr). Agar $S = r^2$ bo'lsa $\Omega = 1$ sr. Butun sfera bo'yicha fazoviy burchak $\Omega = 4\pi$.



6. Birlik fazoviy burchak bo'yicha tarqalayotgan yorug'lik oqimi **yorug'lik kuchi** I deyiladi: $I = \frac{\Delta\Phi}{\Delta\Omega}$ yoki $I = \frac{\Phi}{\Omega}$. Birligi $[I] = 1$ kd (kandela) $= \frac{1\ \text{lm}}{1\ \text{sr}}$.



7. Nuqtaviy manba uchun $\Phi = \Omega \cdot I = 4\pi \cdot I$, chunki $\Omega = 4\pi$.

8. Yuza birligiga normal tushayotgan yorug'lik oqimiga **yoritilganlik** deyiladi:

$$E = \frac{\Delta\Phi \cdot \cos\alpha}{\Delta S} = \frac{\Phi_n}{S} = \frac{\Phi}{S_n}.$$

Birligi $[\Phi] = \frac{1\ \text{lm}}{1\ \text{m}^2} = 1\ \text{lk}$ (lyuks),

texnikada $[\Phi] = 1\ \text{ft (fot)} = \frac{1\ \text{lm}}{1\ \text{sm}^2}$, 1 ft = 10^4 lk.

9. **Nuqtaviy manba uchun** $E = \frac{I}{r^2} \cdot \cos\alpha$, bu yerda r – manbadan yuzagacha bo'lgan masofa, α – tushish burchagi.

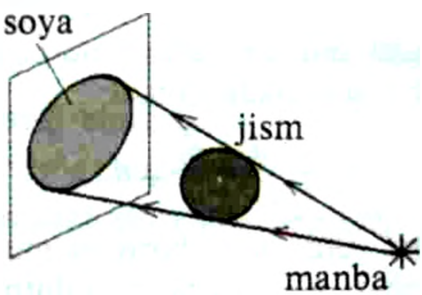
10. **Manbaning nurlanuvchanligi (ravshanligi)** – bu manba sirtining yuza birligidan nurlanayotgan yorug'lik oqimidir: $R = \frac{\Delta\Phi}{\Delta S}$ yoki $R = \frac{\Phi}{S}$, birligi: $[R] = \frac{1\ \text{lm}}{1\ \text{m}^2}$.

11. **Yorug'lik oqimi yoki yorug'lik kuchi** biror yuzaning yoritilganligi yoki shu yuzaga o'rnatilgan fotoelement asosida fotoeffekt hodisasiga binoan taqqoslash asosida o'rganiladi va aniqlanadi:

$$\left.\begin{aligned} i_e &= c \cdot \Phi_e = c \cdot E_e \cdot S, \\ i_x &= c \cdot \Phi_x = c \cdot E_x \cdot S, \end{aligned}\right\}$$

bundan $i_x = i_e \cdot \frac{E_x}{E_e} = i_e \cdot \frac{\frac{I_e}{r^2}}{\frac{I_x}{r^2}} = i_e \cdot \frac{I_e}{I_x}$, bu yerda c – proporsionallik koeffitsiyenti. Oxirgi tenglikdan E_x yoki I_x ni aniqlash mumkin.

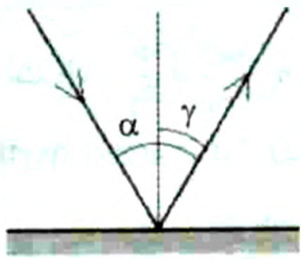
4.2. Yorug'lik tabiati. Yorug'likning qaytish va sinish qonuni



1. **Yorug'lik** – elektromagnit to'lqin (ko'ndalang to'lqin).

2. Yorug'lik bir jinsli muhitda to'g'ri chiziq bo'yicha tarqaladi.

3. **Yorug'lik nuri** – yorug'likning (energiyasini) tarqalish yo'nalishini ko'rsatuvchi to'g'ri chiziqdir.



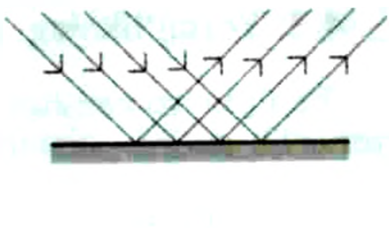
$\alpha = \gamma$

4. **Yorug'likning qaytish qonunlari:**

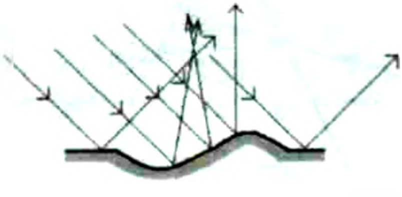
a) tushuvchi nur, qaytgan nur va tushish nuqtasiga o'tkazilgan perpendikular bir tekislikda yotadi;

b) γ qaytish burchagi α tushish burchagiga teng, $\alpha=\gamma$.

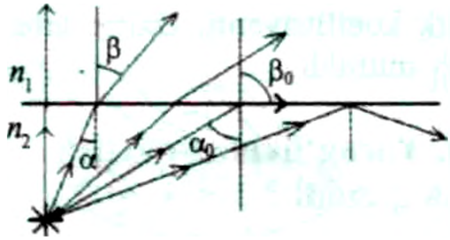
5. **Yorug'likning qaytishi:**



a) agar yuzaga tushuvchi parallel nurlar yuzasidan qaytganda ham o'zaro parallelligini saqlasa, bunday qaytish **ko'zgu qaytish** deyiladi;



b) agar yuzaning notekislik o'lchami yorug'lik dastasi o'lchamidan katta bo'lsa, unda yorug'lik barcha yo'nalishlarda qaytadi va bu yorug'likning **sochilishi** yoki **diffuz qaytishi** deyiladi.



6. **Yorug'likning sinish qonunlari** (yorug'likning ikki muhit chegarasidan o'tganda yo'nalishini o'zgarishiga yorug'likning sinishi deyiladi):

a) tushuvchi nur, singan nur va tushish nuqtasiga o'tkazilgan perpendikular bir tekislikda yotadi;

b) $\frac{\sin\alpha}{\sin\beta} = \frac{n_2}{n_1} = n$,

bu yerda n_1 – birinchi muhitning, n_2 – ikkinchi muhitning, n – ikkinchi muhitning birinchi muhitga nisbatan nisbiy sindirish ko'rsatkichi;

$$n = \frac{n_2}{n_1} = \frac{v_1}{v_2}, \text{ chunki } n_1 = \frac{c}{v_1} \text{ va } n_2 = \frac{c}{v_2};$$

d) To'la ichki qaytish ($n_2 < n_1$):

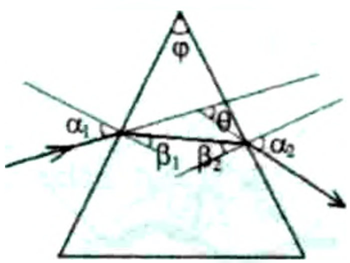
$$\frac{\sin\alpha_0}{\sin\beta} = \frac{n_1}{n_2} = \frac{1}{n}; \ \sin\alpha_0 = \frac{1}{n}; \ \beta_0 = 90°; \ \alpha_0 = \arcsin\frac{1}{n};$$

to'la ichki qaytish boshlanadigan eng kichik burchak chegaraviy (α_0) burchak deyiladi.

4.3. Yorug'likning shaffof jismlardan o'tishi

Berilgan yo'nalishga (optik o'qqa) parallel bo'lgan yorug'lik nurlari paraksial nurlardir.

1. Yorug'likning prizmadan o'tishi:



$$\theta = \alpha_1 + \alpha_2 - \varphi, \quad \beta_1 + \beta_2 = \varphi,$$

$$\frac{\sin\alpha_1}{\sin\beta_1} = n, \quad \frac{\sin\alpha_2}{\sin\beta_2} = n.$$

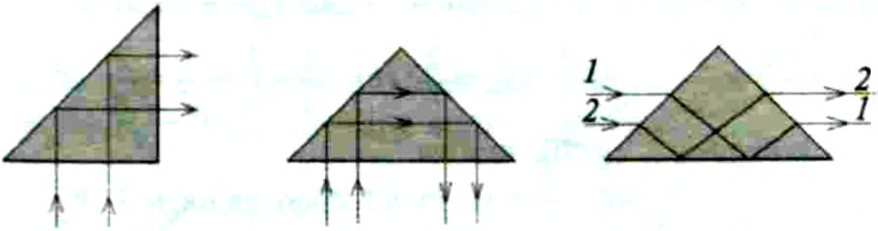
Agar $\alpha_1 = \alpha_2$ bo‘lsa, $\theta = 2\alpha - \varphi$.

Prizmaning sindirish ko‘rsatkichi:

$$n = \frac{\sin\left(\frac{\theta}{2} + \frac{\varphi}{2}\right)}{\sin\frac{\varphi}{2}},$$

Prizmaning eng katta sindirish burchagi $\varphi_{max} = 2\beta_R$, bu yerda β_R – to‘la ichki qaytishning chegaraviy burchagi.

2. Yorug‘likning to‘g‘ri burchakli prizmadan o‘tishi:



a) *b)* *d)*

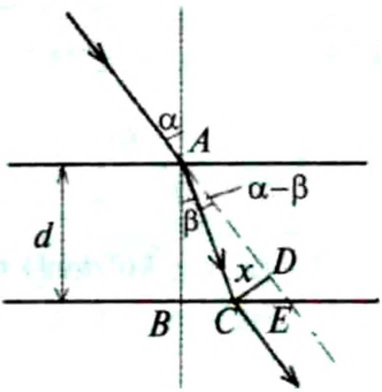
3. Yorug‘likning yassi-parallel plastinkadan o‘tishida nurning siljishi:

$$x = AC\sin(\alpha - \beta); \quad AC = \frac{d}{\cos\beta};$$

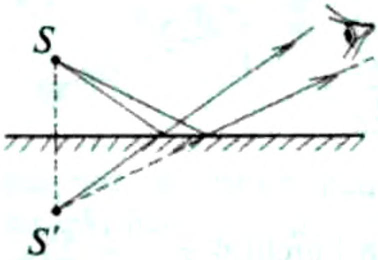
$$x = \frac{d}{\cos\beta}\cdot\sin(\alpha - \beta) =$$
$$= d(\sin\alpha - \cos\alpha\cdot \mathrm{tg}\beta)$$

yoki

$$X = d\left(1 - \frac{\cos\alpha}{\sqrt{n^2 - \sin^2\alpha}}\right)\cdot\sin\alpha.$$



4.4. Ko'zgu



1. Yassi ko'zguda tasvir.

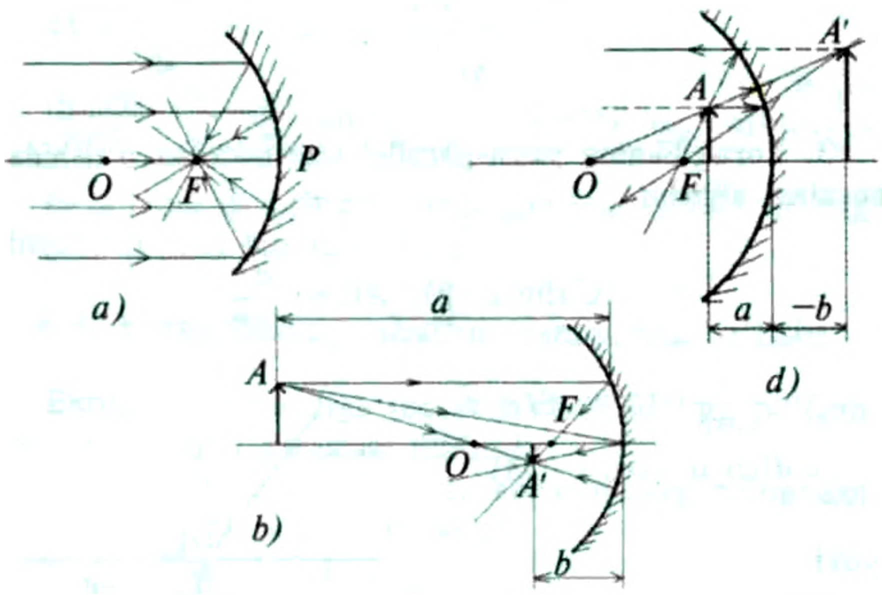
Tasvir to'g'ri, mavhum, kattaligi predmet o'lchami bilan bir xil, ko'zgu orqasida predmetdan ko'zgugacha bo'lgan masofadagicha vaziyatda bo'ladi.

2. Botiq ko'zguda nurlar yo'li va tasvir:

a) Fokus masofasi; b) tasvir haqiqiy, teskari ($a > f$); d) tasvir mavhum, to'g'ri ($a < f$), ko'zgu formulasi:

$$f = \frac{OP}{2} = \frac{R}{2}, \quad \frac{1}{a} + \frac{1}{b} = \frac{1}{f} = \frac{2}{R} \ (b), \quad \frac{1}{a} - \frac{1}{b} = \frac{1}{f} = \frac{2}{R} \ (d),$$

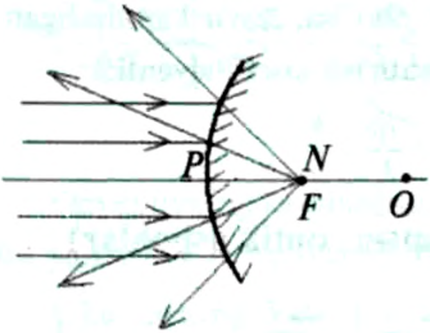
R — ko'zguning egrilik radiusi.

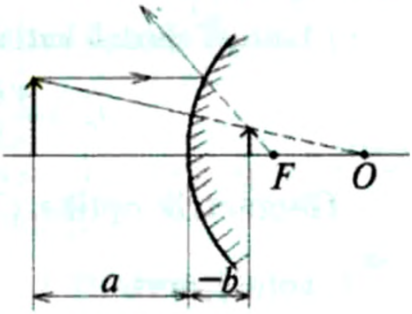


3. Qavariq ko'zguda nurlar yo'li va tasvir:

a) fokus masofasi: b) tasvir mavhum, to'g'ri:

$$f = PN = \frac{OP}{2} = \frac{R}{2} \qquad \frac{1}{a} - \frac{1}{b} = -\frac{1}{f} = -\frac{2}{R}$$





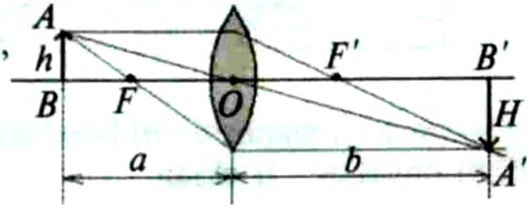
4. Linzaning fokus masofasi: $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$,

bu yerda n – linza moddasining sindirish ko'rsatkichi; R_1 va R_2 – linza sirtining egrilik radiuslari.

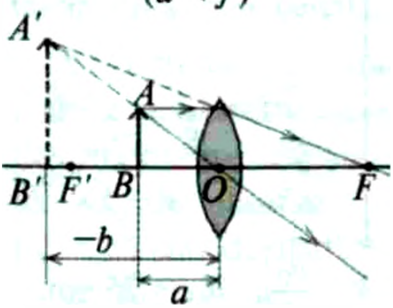
5. Linzaning optik kuchi $D = \frac{1}{f}$, birligi $[D]$ = 1 dptr (dioptriy).

6. Yupqa linzalarda tasvir.

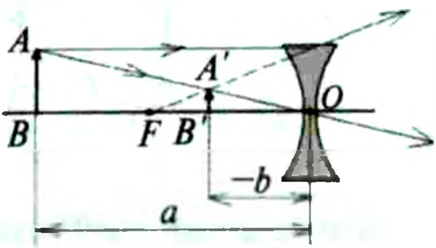
a) Tasvir haqiqiy, teskari



b) Tasvir mavhum ($a < f$)



d) Sochuvchi linzada tasvir mavhum, to'g'ri



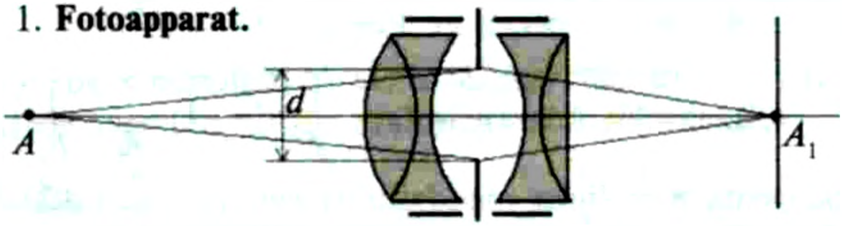
$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}=D$ — linza formulasi. Agar $a > 2f$ bo'lsa, tasvir kichiklashgan, $2f > a > f$ bo'lsa, tasvir kattalashgan.

b) **Linzani chiziqli kattalashtirish koeffitsiyenti:**

$$G=\frac{A'B'}{AB}=\frac{H}{h}=\frac{b}{a}.$$

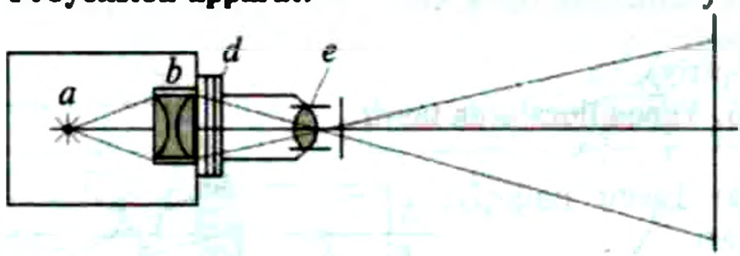
Geometrik optika (3-qism, optik asboblar)

1. **Fotoapparat.**



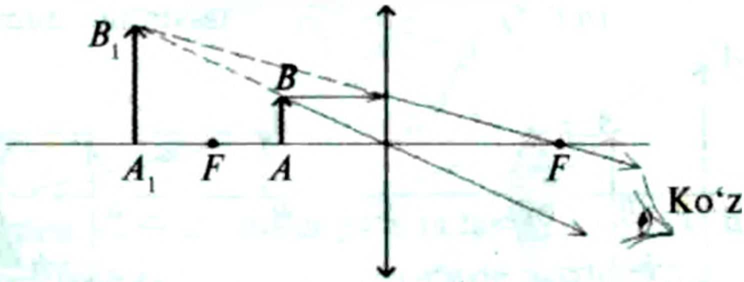
d — diafragma kengligi.

2. **Proyeksion apparat.**



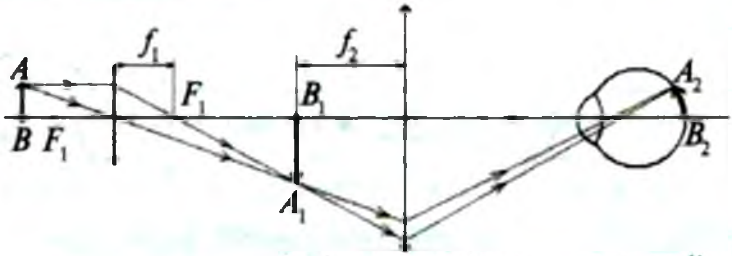
a) yoritish manbayi; b) kondensor; d) kadr plyonkasi; e) obyektiv; f) ekran.

3. **Lupa** (fokus masofasi $f \leq 10$ sm).



Kattalashtirish koeffitsiyenti: $k=\frac{d_0}{f}$, $d_0 = 25$ sm.

4. Mikroskop.



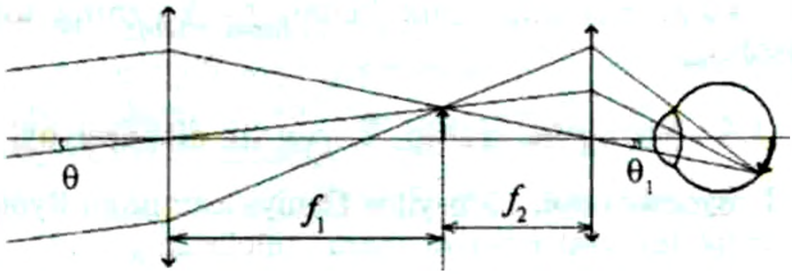
Obyektivning kattalashtirish koeffitsiyenti $k_1 \approx \frac{v}{a} \approx \frac{l}{f_1}$, bu yerda $b \approx l$ — tubusning uzunligi.

Okulyarning kattalashtirish koeffitsiyenti: $k_2 = \frac{d_0}{f_2}$, $d_0 = 25$ sm.

Mikroskopning umumiy kattalashtirishi:

$$k = k_1 \cdot k_2 = \frac{ld_0}{f_1 \cdot f_2}.$$

5. Teleskop.

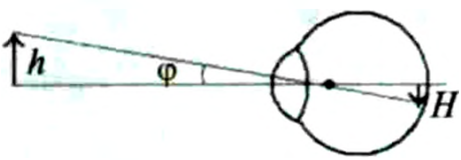


Teleskopning kattalashtirish koeffitsiyenti: $k = \frac{\theta_1}{\theta} = \frac{f_1}{f_2}$.

6. **Koʻz.**

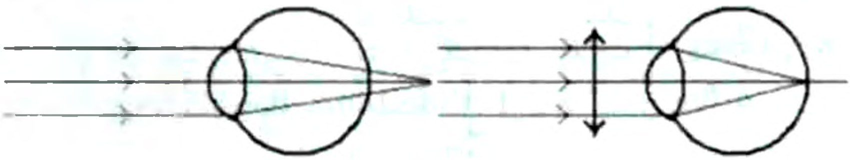
a) Koʻrish burchagi — koʻz toʻrida hosil boʻladigan tasvir kattaligini belgilaydi.

b) Uncha kuchlanishsiz predmetni koʻrish masofasiga eng yaxshi koʻrish masofasi (d_0 = 25 sm) deyiladi.

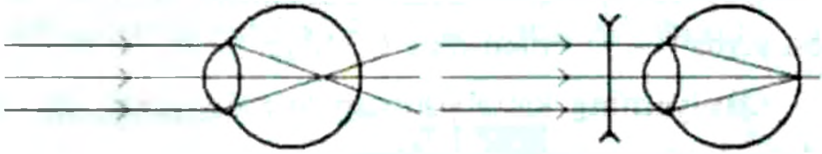


d) Koʻzoynak.

1) uzoqni ko'rish (ko'zning optik kuchi kam, yetarli emas).



2) yaqinni ko'rish (ko'zning optik kuchi katta).



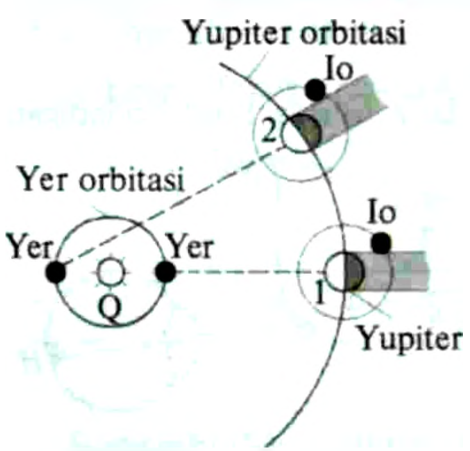
$$\frac{1}{d_0}+\frac{1}{f}=D_1+D; \quad \frac{1}{d_1}+\frac{1}{f}=D_1; \quad D=\frac{1}{d_0}-\frac{1}{d_1};$$

bu yerda D_1 — o'quvchi ko'zining optik kuchi; d_1 — o'quvchi ko'zining zo'riqmasdan o'qiydigan masofasi; D — ko'zoynakning optik kuchi, f — ko'zning fokus masofasi.

4.5 . Yorug'lik tezligi. Yorug'lik dispersiyasi

1. **Ryomer usuli.** 1676-yilda Daniya astronomi Ryomer yorug'lik tezligini birinchi marta aniqlagan:

$$c = 2,15 \cdot 10^8 \text{ m/s}.$$



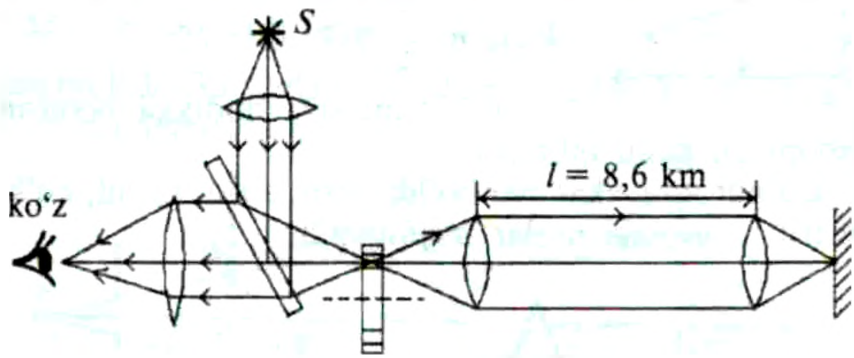
Yupiterning Io yo'ldoshi uning soyasida 2-holda 1-holga nisbatan $\Delta t = 22$ minut uzoq bo'lgan. Bu vaqt Yerning vaziyatiga bog'liq va masofalar farqi yer orbitasining diametriga teng deb, $c=\frac{d}{\Delta t}$ dan yorug'lik tezligi aniqlangan.

2. **Fizoning laboratoriya usuli** (1849-y.).

$$c = \frac{2nl\omega_0}{\pi},$$

$$c = 3{,}13 \cdot 10^8 \text{ m/s},$$

bu yerda n – g'ildirak tishlari soni; ω_0 – g'ildirakning manbayini tasviri doimiy ko'rinadigan burchak tezligi.

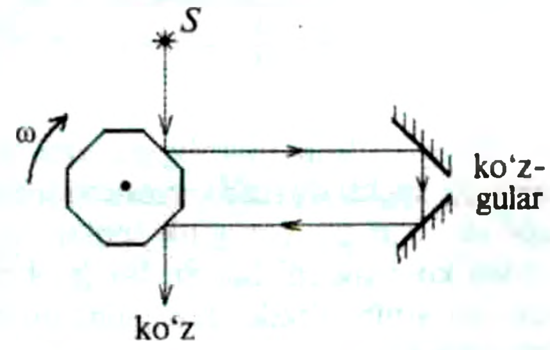


3. **Maykelson usuli** (1929-y.).

ω – ko'zguli 8 yoqlikning aylanish burchak tezligi bo'lib, u shunday tanlanadiki, unda manbaning tasviri doimiy ko'rinib turadi:

$$c = \frac{8l\omega_0}{\pi},$$

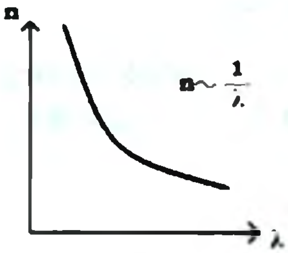
$$c = 2{,}99796 \cdot 10^8 \text{ m/s}.$$



4. Hozirgi zamon ma'lumotlariga asosan yorug'likning vakuumdagi tezligi:

$$c = (299792456{,}2 \pm 0{,}8) \text{ m/s} \approx 3 \cdot 10^8 \text{ m/s}.$$

Muhitdagi tezligi $\upsilon = \frac{c}{n} = \frac{c}{\sqrt{\varepsilon\mu}}$, ya'ni yorug'likning muhitdagi tezligi uning vakuumdagi tezligidan n marta kichik bo'ladi.

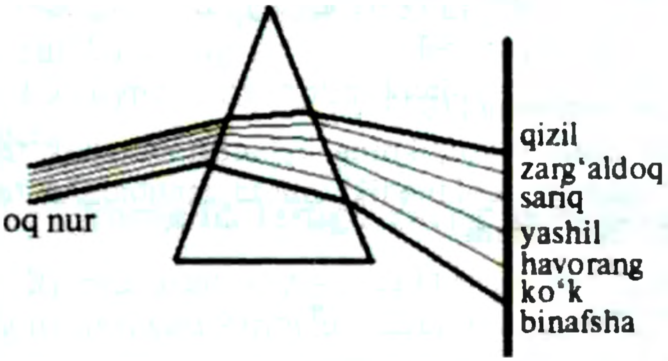


4. **Yorug'lik dispersiyasi.**

a) Muhitning sindirish ko'rsatkichini unga tushayotgan yorug'likning to'lqin uzunligiga (chastotasiga) bog'liqligiga dispersiya deyiladi, $n \sim \frac{1}{\lambda}$ yoki $n \sim \nu$.

b) Dispersiya hodisasi Nyuton tomonidan kashf qilingan.

Oq nur murakkab nur bo'lib, qizil, sariq, yashil, ko'k, binafsha rangdagi nurlar majmuasidir.



Aniq to'lqin uzunligiga ega bo'lgan yorug'likning qismiga spektr deyiladi, monoxromatik yorug'lik ham deb ataladi. Har bir yorug'lik spektri uchun prizmaning sindirish ko'rsatkichi har xil bo'lgani uchun ular prizmadan har xil sinib o'tadi. Natijada, oq nur har xil nurlar – spektrlarga ajraladi.

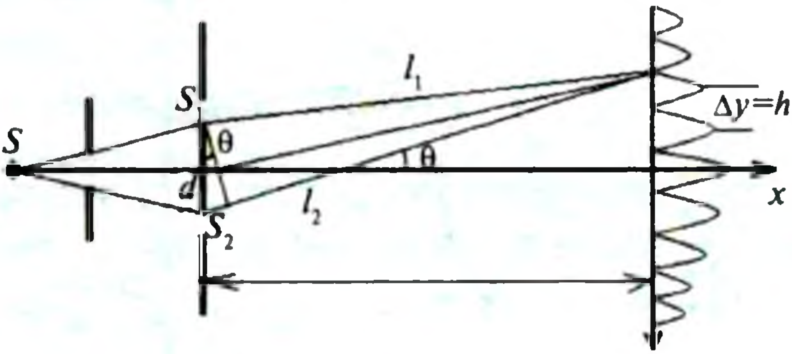
d) Monoxromatik nur (spektr) havodagi boshqa zichroq muhitga o'tganda uning to'lqin uzunligi $\lambda = \frac{\lambda_0}{n}$ kamayadi, chastotasi va rangi o'zgarmaydi.

e) barcha rangdagi nurlar qo'shilib, yana oq nurni hosil qiladi.

4.6. Yorug'likning to'lqin xossalari

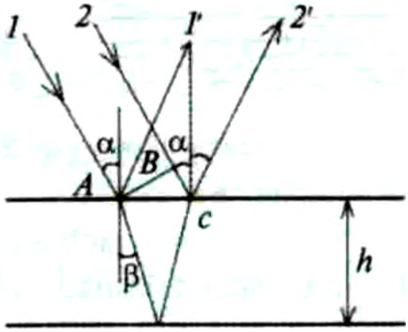
1. **Interferensiya** – ikkita kogerent to'lqinlarning o'zaro qo'shilib bir-birini kuchaytirishi yoki susaytirishidir.

Kogerent to'lqinlar – bu $\omega_1 = \omega_2$ (yoki $\nu_1 = \nu_2$) va fazalar farqi $\Delta\varphi = \text{const}$. Agar optik yo'llar farqi $l_2 - l_1 = \Delta l = k\lambda$ bo'lsa – max, $l_2 - l_1 = \Delta l = (2k+1)\frac{\lambda}{2}$ bo'lsa min bo'ladi. Bu yerda λ – to'lqin uzunligi, $k = 0, \pm1, \pm2, \ldots$ – interferensiya tartibi.



a) Yung tajribasi $\Delta l = k\lambda$ da, maksimum yoki minimumlar orasidagi masofa $\Delta y = h = \frac{\lambda L}{d}$. Fazalar farqi: $\Delta\varphi = \frac{2\pi}{\lambda} \cdot \Delta l$.

b) Yassi plastinkada interferensiya. Qaytgan nurlar uchun optik yo'llar farqi $\Delta l = 2hn \cdot \cos\beta + \frac{\lambda}{2}$, bu yerda n – plastinka moddasining sindirish ko'rsatkichi.



$\cos\beta \approx 1$ bo'lsa,

$$\Delta l = 2hn + \frac{\lambda}{2} = 2k \cdot \frac{\lambda}{2} \quad \text{(max)},$$

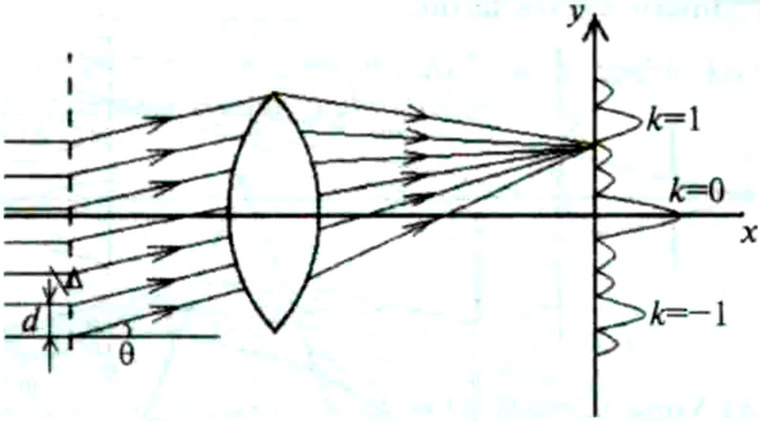
$$2hn = (2k-1)\frac{\lambda}{2} \quad \text{(min)}.$$

$$\Delta l = (AD + DC)n - BC$$

$$k = 1 \text{ da } 2hn = \frac{\lambda}{2} \Rightarrow h = \frac{\lambda}{4n}.$$

2. **Difraksiya** – yorug'likning to'siqdan (difraksion panjaradan) o'tganda tarqalish yo'nalishidan og'ishidir.

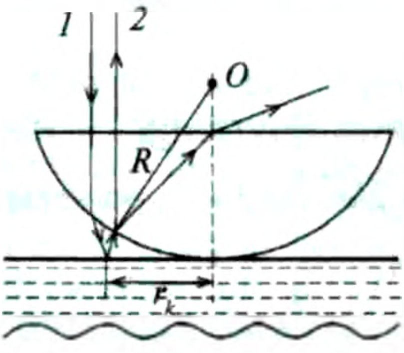
Yo'llar farqi $\Delta = d \sin\theta = k\lambda$ (max sharti), bu yerda d – panjara doimiysi; N – panjaralar soni. Difraksion panjaraning ajrata olish qobiliyati $R = k_{max} \cdot N$.



3. **Nyuton halqalari.** Qaytgan nurlarda xira halqalar uchun $r_k = \sqrt{k\lambda R}$ va yorug' halqalar uchun

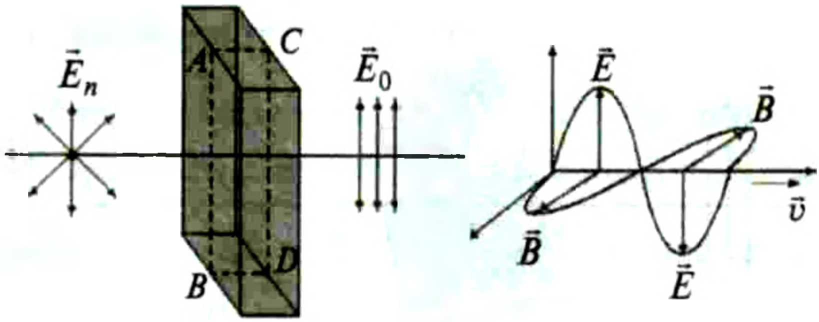
$$r_k = \sqrt{(2k+1)\frac{\lambda}{2} R},$$

bu yerda r_k – k- halqaning radiusi.



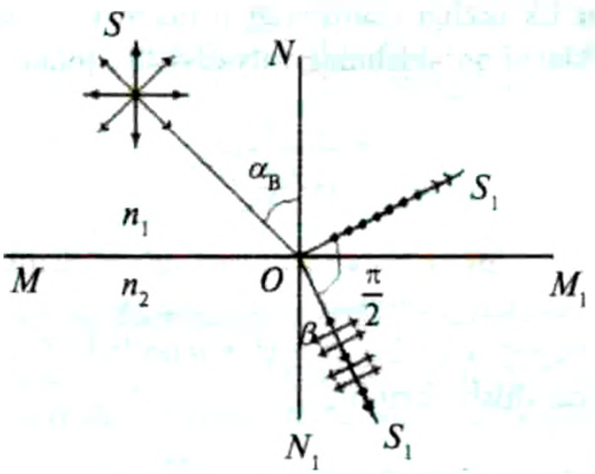
4. a) **Yorug'likning qutblanishi uning ko'ndalang to'lqin ekanligini isbot qiladi.**

Yorug'likning qutblanishi – uning $\bar{E}$ yoki $\vec{B}$ vektorining bitta tekislikda tebranishidir.



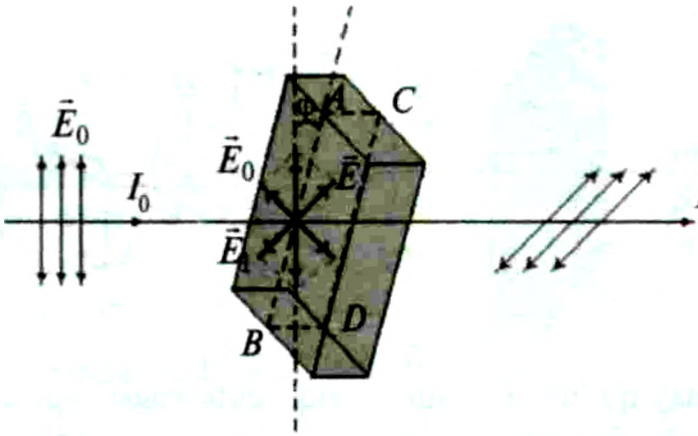
Bunday qutblangan nur chiziqli qutblangan nur deyiladi. Uning $\vec{B}$ vektori – tebranayotgan tekislik to'lqinning qutblanish tekisligi, $\vec{E}$ vektori – tebranayotgan tekislik esa **tebranish tekisligi** deyiladi.

b) **Tabiiy yorug'lik** nuri α_B – Bryuster burchagi ostida dielektrikka tushganda undan qaytgan nur to'la qutblangan bo'ladi. Qaytgan nur bilan singan nur orasidagi burchak 90° bo'lgani uchun $\operatorname{tg}\alpha_B = n = \frac{n_2}{n_1}$ bo'ladi.



Bu ifoda **Bryuster qonuni** deyiladi. Singan nur esa qisman qutblangan bo'ladi.

d) **Malyus qonuni** I_0 – intensivlikdagi qutblangan nur analizator (turmalin, kvars va b.)dan o'tgandagi inten-



sivligi $I = I_0 \cos^2 \alpha$, bu yerda α — qutblanish tekisligi bilan kristall o'qi orasidagi burchak.

4.7. Nisbiylik nazariyasi elementlari

1. **Nisbiylik nazariyasi (NN) postulatlari:**

a) nisbiylik prinsipi (har qanday fizik jarayonlar barcha inersial sanoq sistemalarida bir xil o'tadi);

b) yorug'lik tezligi doimiyligi prinsipi (c = const).

2. **Tezliklarni qo'shishning relyativistik qonuni:**

$$v = \frac{v' + u}{1 + \frac{v' \cdot u}{c^2}},$$

bu yerda u — sanoq sistemasining, v' — jismning shu sistemaga nisbatan tezliklari.

Agar v' va $u \ll c$ bo'lsa, $v = v' + u$ bo'ladi (Galileyning tezliklarni qo'shish formulasi).

3. **Voqealar orasidagi vaqt:** $\tau = \dfrac{\tau_0}{\sqrt{1 - \frac{v^2}{c^2}}}$,

bu yerda τ_0 — voqea ro'y bergan sistemadagi xususiy vaqt.

4. **Jismning relyativistik uzunligi:** $l = l_0\sqrt{1-\frac{\upsilon^2}{c^2}}$,

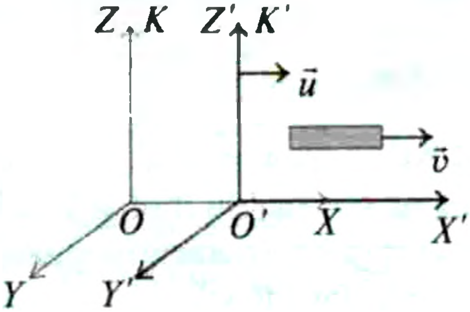
l_0 — jismga nisbatan qo'zg'almas sistemadagi uzunligi.

5. **Jism massasining tezlikka bog'liqligi** (relyativistik massasi): $m = \frac{m_0}{\sqrt{1-\frac{\upsilon^2}{c^2}}}$, bu yerda m_0 — jismning tinchlikdagi massasi, υ — uning tezligi.

Agar $\upsilon \ll c$, $\frac{\upsilon^2}{c^2} \approx 1$, bo'lsa $m = m_0$.

6. **Jismning relyativistik impulsi:**

$$\vec{K} = m\vec{\upsilon}, \quad \vec{K} = \frac{m_0\upsilon}{\sqrt{1-\frac{\upsilon^2}{c^2}}}.$$



7. **Jismning tinchlikdagi energiyasi:** $E_0 = m_0c^2$.

8. Har qanday o'zaro ta'sirda jismning to'liq energiyasining o'zgarishi ΔE bilan uning massa o'zgarishi orasidagi bog'lanish:

$$\Delta E = \Delta mc^2, \quad \Delta Q = Cm\Delta t = \Delta mc^2, \quad \Delta m = \frac{Cm\Delta t}{c^2}.$$

9. **Harakatdagi jismning to'liq energiyasi:** $E = mc^2$.

10. **Harakatdagi jismning kinetik energiyasi:**

$$E_k = E - E_0 = m_0c^2\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1\right), \text{ agar } v \ll c, \text{ bo'lsa}$$

$$E_k \approx \frac{m_0v^2}{2}.$$

4.8. Yorug'likning kvant xossalari. Fotoeffekt

1. **Yorug'lik nurlanishi, elektromagnit nurlanish diskret energiya porsiyasi-foton (nurlanish kvanti)dan iborat** (M. Plank. 1900-y.).

2. **Foton energiyasi:**

$E = h\nu$, bu yerda $h = 6{,}625 \cdot 10^{-34}$ J · s (Plank doimiysi)

3. **Fotonning tinch holatdagi massasi:** $m_0 = 0$, $\hbar = \frac{h}{2\pi}$,

harakatdagi massasi: $m = \frac{h\nu}{c^2}$.

4. **Fotoeffekt** — bu yorug'lik ta'sirida jismlardan elektronlarning ajralib chiqishi (tashqi fotoeffekt), zaryadlarning (elektronlar va kovaklarning) o'tkazuvchanlik zonalariga o'tishi (ichki fotoeffekt).

5. **Tashqi fotoeffekt qonunlari:**

a) to'yinish fototoki, ya'ni jismdan 1 s da ajralib chiquvchi elektronlar soni tushuvchi yorug'lik oqimiga proporsionaldir ($i_f \sim \Phi$);

b) fotoelektronning kinetik energiyasi tushuvchi yorug'likning oqimiga bog'liq emas, chastotasiga to'g'ri proporsionaldir: $\frac{mv^2}{2} \sim \nu$.

d) fotoeffekt uchun energiyaning saqlanish qonuni (Eynshteyn):

$$h\nu = A + \frac{mv^2}{2} \text{ — Eynshteyn formulasi (1905-y).}$$

bu yerda $h\nu$ — foton energiyasi; A — chiqish ishi; $\frac{mv^2}{2}$ — elektronning kinetik energiyasi. $h\nu \geq A$ — fotoeffekt ro'y berish sharti;

e) har qanday jismda fotoeffekt ro'y berishi uchun yorug'lik chastotasining chegaraviy qiymati mavjud, ya'ni fotoeffektning qizil chegarasi:

$$h\nu_{min} = A, \quad \nu_{min} = \frac{A}{h} \text{ yoki } \lambda_{max} = \frac{hc}{A};$$

f) fotoeffekt hodisasi — inersiyasiz hodisadir.

6. **Yorug'lik bosimi** — fotonlarning biror yuzaga urilishi natijasida impulsini berishdir.

Yorug'lik bosimi Maksvell (1864-y.) tomonidan bashorat qilinib tajribada A. Lebedev (1900-y.) tomonidan o'lchangan. Foton impulsi:

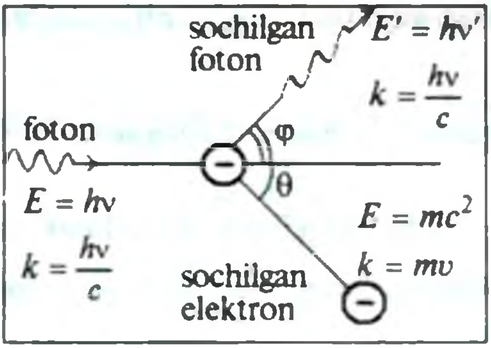
$$K = m \cdot c = \frac{h\nu}{c}, \quad p = \frac{E}{c}(1 + \rho), \quad E = \frac{\Phi}{S_n},$$

bu yerda ρ — yuzaning qaytarish koeffitsiyenti;

$p_0 = 4{,}8 \cdot 10^{-8}$ Pa amalda o'lchangan maksimal bosim qiymati.

7. **Dopler effekti** — atomning nurlanish chastotasining siljishi $\frac{\Delta\nu}{\nu} = \frac{v}{c} \cdot \cos\theta$, bu yerda θ — atom yo'nalishi bilan nurlanish yo'nalishi orasidagi burchak.

8. **Kompton effekti** (1922-y). Foton elektron bilan to'qnashganda o'zining impulsi va energiyasini bir qismini elektronga beradi.



Tushayotgan yorug'lik to'lqin uzunligining o'zgarishi:

$$\Delta\lambda = \lambda_1 - \lambda_2 = \frac{h}{m_0 c}(1 - \cos\varphi),$$

$\frac{h}{m_0 c} = \lambda_K = 2,4 \cdot 10^{-10}$ m — Kompton to'lqin uzunligi. Bu effekt — yorug'likning kvant xossasini isbotidir.

4.9. Nurlanish va spektrlar

1. **Yorug'lik** — bu to'lqin uzunligi $\lambda = 4 \cdot 10^{-7} \div 8 \cdot 10^{-7}$ m intervalda bo'lgan elektromagnit to'lqindir.

Atom nurlanishi uchun unga doimiy energiya berilib turilishi kerak.

2. Modda yoki jismning nurlanishdagi to'lqinlar (chastotalar) majmuasi **nurlanish spektri** deyiladi.

a) Qattiq yoki suyuq holatda bo'lgan moddalarning nurlanish spektri uzluksiz, tutash bo'ladi;

b) gaz holatida — atomar holatda moddalar nurlanish spektri chiziqli (diskret) bo'ladi.

3. Jism yoki moddadan yorug'lik nuri o'tganda, uning ma'lum qismi — spektri yutiladi. Bunga **yutilish spektri** deyiladi. Barcha moddalar o'zi nurlay oladigan to'lqin uzunliklardagi yorug'likni — spektrni yutadi.

4. **Spektral analiz (tahlil)** — moddaning nurlanish yoki yutilish spektrlariga qarab uning kimyoviy tarkibini aniq-

lashdir. Spektral analiz barcha sohalarda moddalar tarkibini tekshirishda qo'llaniladi.

5. **Spektroskop** – yorug'lik tarkibi – spektrlarni o'rganuvchi asbobdir.

Spektrografda esa tarkib analizi natijasi rasmda yoki grafik usulda olinadi.

6. **Infraqizil nurlar** – qizil nurlar sohasi ortida joylashgan bo'lib, to'lqin uzunligi $\lambda = 4\cdot10^{-3} \div 8\cdot10^{-7}$ m intervalda va ko'zga ko'rinmaydi.

Manbayi: barcha haroratga ega bo'lgan jism va moddalar.

Xossalari: ko'zga ko'rinmas, jismlarda yaxshi yutiladi, jismlarning qarshiligini o'zgartiradi, fotomateriallarga ta'sir qiladi, tumandan yaxshi o'tadi.

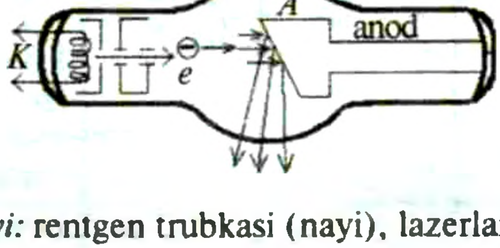
7. **Ultrabinafsha nurlar.** Binafsha nurlar sohasidan pastda, undan yuqori chastotalarda bo'lgan va ko'zga ko'rinmaydigan nurlar **ultrabinafsha nurlar** deyiladi.

Uning to'lqin uzunligi binafsha nur $\lambda = 4\cdot10^{-7}$ m va rentgen nurlari $\lambda = 10^{-8}$ m orasida bo'ladi.

Manbayi: quyosh, kosmos, lazer, gaz chaqnash lampalari.

Xususiyatlari: fotoelementlarga, lyuminissent moddalarga, bakteriyalarga ta'sir qiladi, ozon tomonidan kuchli yutiladi, davolash xususiyatlariga ega.

8. **Rentgen nurlari** (V. Rentgen 1895- yilda kashf etgan). To'lqin uzunligi $\lambda = 4\cdot10^{-8} \div 10^{-12}$ m, intervalda bo'lgan elektromagnit to'lqinlar **rentgen nurlari** deyiladi.



Manbayi: rentgen trubkasi (nayi), lazerlar, quyosh toji, betatron.

$P = 10^{-6} \div 10^{-8}$ mm sim. ust., $U_{anod} = 40 \div 100$ kW.

Xususiyatlari: ko'zga ko'rinmas, deyarli barcha jismlardan o'tadi, lyuminessensiya paydo qiladi, fotoemulsiyaga ta'sir qiladi, gazlarni ionlaydi.

Qo'llanishi: rentgenostruktura tahlili, rentgenoterapiya, rentgenografiya.

9. **Elektromagnit to'lqin shkalasi, turlari, manbalari.**

	Nurlanish turlari	Chastotalar oralig'i, Hz	To'lqin uzunliklari oralig'i, m	Nurlanish manbalari
1	Past chastotali	$0 \div 3 \cdot 10^3$	$0 \div 10^5$	Yuqori chastotali toklar, o'zgaruvchan tok generatori, elektr mashinalari
2	Radio to'lqinlar	$3 \cdot 10^3 \div 3 \cdot 10^4$	$10^5 \div 10^{-3}$	Tebranish konturi, Gers vibratori, lazerlar, yarim o'tkazgichli asboblar
3	Infraqizil nurlanish	$3 \cdot 10^{11} \div 4 \cdot 10^{14}$	$2 \cdot 10^{-3} \div 7{,}6 \cdot 10^{-7}$	Quyosh, elektrolampalar, yuqori haroratli jismlar, lazerlar, kosmos, simob-kvars lampalari
4	Ko'rinuvchan nurlar	$4 \cdot 10^{14} \div 8 \cdot 10^{14}$	$7{,}7 \cdot 10^{-7} \div 3{,}8 \cdot 10^{-7}$	Quyosh, elektrolampalar, yuqori haroratli jismlar, lazerlar, lyuminessensiya, gaz chaqnashlari
5	Ultrabinafsha nurlar	$7{,}3 \cdot 10^{14} \div 3 \cdot 10^{17}$	$4 \cdot 10^{-7} \div 3 \cdot 10^{-8}$	Quyosh, kosmos, lazerlar, elektr lampalar

6	Rentgen nurlari	$3\cdot10^{16}\div 3\cdot10^{20}$	$10^{-8}\div10^{-12}$	Rentgen trubkasi, lazerlar, betatron, Quyosh toji, samoviy jismlar
7	Gamma nurlar	$3\cdot10^{19}\div 3\cdot10^{29}$	$10^{-11}\div10^{-13}$	Kosmos, radioaktiv yemirilish, betatron

10. **Yorug'likning kimyoviy ta'siri** – moddalarning yorug'likni yutishi natijasida moddada kimyoviy-fotokimyoviy reaksiyalarning ro'y berishidir.

a) Fotosintez – o'simliklarni CO_2 gazini yutib, uni yorug'lik ta'sirida parchalashi: $CO_2 \rightarrow C + O_2$ (A. Temiryazev).

b) Fotografiya:

– kumush bromidning (AgBr) yorug'lik ta'sirida parchalanishi,

– yorug'lik ta'sirida kumush ajralishi,

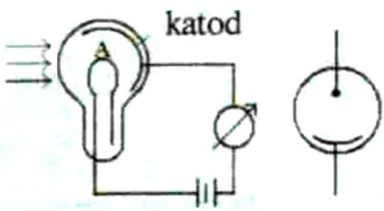
– fotokopiya – fotoplyonkadan tasvirni fotoqog'ozga o'tkazish.

11. **Yorug'likning issiqlik ta'siri** – yorug'likni yutilishi natijasida jismning haroratini ortishi, ya'ni yorug'lik energiyasini jismning ichki energiyasiga aylanishidir.

12. **Lyuminessensiya** – nur energiyasini boshqa turdagi energiyaga, boshqa turdagi energiyani nur yorug'lik energiyasiga aylanishidir.

Lyuminessensiya: 1) fluoressensiya – yoritilib turganda nurlanadi, nurlanish to'xtashi bilan jism nurlanmaydi; 2) fosforessensiya – yoritilish to'xtagandan so'ng jismning nurlanishidir.

13. **Fotoelementlar.**



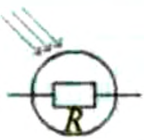
Fotoelementlar: 1) vakuumli (tashqi fotoeffekt asosidagi);

2) yarimo'tkazgichli (ichki fotoeffekt asosidagi).

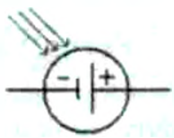
a) Vakuumli fotoelement yorug'lik energiyasini elektr energiyasiga aylantirib beruvchi yoki elektr toki hosil qilib uni boshqaruvchi asbobdir.

b) Yarimo'tkazgichli fotoelementlar – yorug'lik energiyasini elektr energiyasiga aylantirib beruvchi yarimo'tkazgichli asbobdir:

1) fotorezistor



2) fotoelement



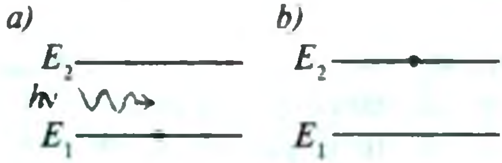
qarshiligi yorug'lik oqimiga bog'liq.

Fotoeffektning texnikada qo'llanilishi: kino, fototelegraf, fototelefon, fotometriya, avtomatika, fotorele, quyosh batareyalarida, Yer sun'iy yo'ldoshlarida elektr manbayi sifatida.

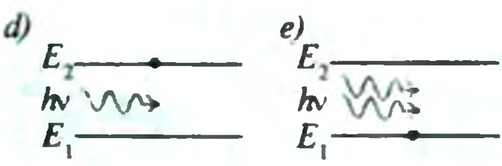
4.10. Lazerlar

Lazer optik kvant generatori bo'lib, monoxromatik va kogerent bo'lgan, hamda ingichka yo'nalishda katta quvvatda nurlanish beruvchi qurilmadir.

1. **Majburiy nurlanish.** Normal sharoitda atom moddalarda minimal energiyali statsionar holatda bo'ladi. Agar u elektromagnit to'lqin bilan ta'sirlansa, u uyg'ongan holatda o'tadi.



Uyg'onmagan atom   Uyg'ongan atom



Majburiy nurlanish

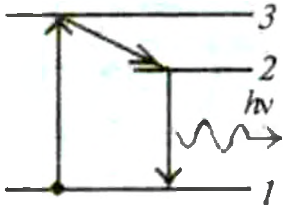
Moddadan yorug'lik o'tganda yutilish jarayonining sxemasi.

Majburiy uyg'onish jarayonining sxematik ko'rinishi. Atom uyg'ongan holatidan o'zining asosiy holatiga foton nurlab o'tadi.

Uyg'ongan atom o'zining avvalgi asosiy majburiy nurlanish holatiga o'tishi.

2. **Lazerning ishlash prinsipi.**

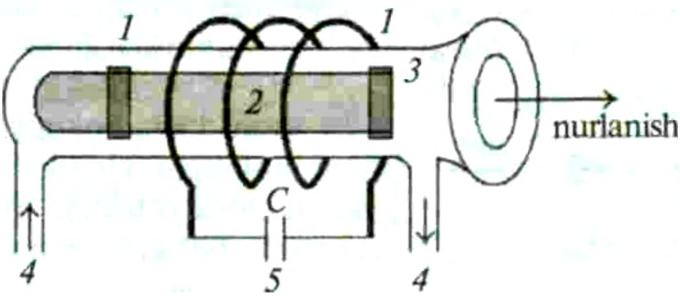
Eng birinchi lazer turi — bu qattiq jism lazeri bo'lib, «yoqut» kristali asosida nurlanish hosil qilingan. Yoqut Al_2O_3 kristalli bo'lib, uning 0,05% aluminiy atomlarining o'rniga Cr ionlari kiritilgan.



Yoqut ko'k-yashil nur bilan nurlantirilganda, xrom ionlari *1* holatdan uyg'ongan *3* holatga o'tadi va juda qisqa vaqtda (10^{-8} s) nurlanishsiz *2* sathga o'tadi. *2* sathda bo'lish vaqti ~10^5 marta ko'p va shuning uchun uyg'ongan holatdagi atomlar soni uyg'onmagan atomlar sonidan juda ko'p bo'ladi.

2 holatdan *1* holatga o'tish tashqi elektromagnit to'lqin ta'sirida nurlanish bilan ro'y beradi. Demak, lazerlar asosan uch sath orqali nurlanish berar ekan.

3. **Yoqut lazerining tuzilishi.** *1* — ko'zgular sistemasi; *2* — yoqut sterjen; *3* — gaz chaqnash lampasi; *4* — sovitish sistemasi; *5* — kondensatorlar batareyasi.

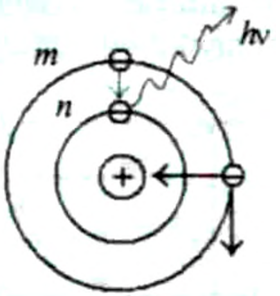


4. **Lazerlar turlari** — faol (aktiv) muhit turiga qarab: qattiq jismli, yarimo'tkazgichli, gaz, kimyoviy, gazodinamik, organik eritmali lazerlar bo'ladi.

Ishlash tamoyiliga qarab: uzluksiz va impuls rejimlarida ishlovchi lazerlar.

5. Ultra qisqa radioto'lqin diapazonida ishlovchi kvant generatorlari — **lazerlar-mazerlar** deyiladi.

5.1. Atom tuzilishi



Rezerford 1911-yilda zarralarning yupqa metall pardadan o'tganda sochilishini o'rganib, zarra elektronlarda emas, yadrolarga yaqinlashib sochilishini kuzatdi va atomning planetar modelini tasdiqladi.

Bunga asosan atom markazida musbat zaryadli yadro bo'lib, uning atrofida elektronlar ma'lum orbitalar bo'yicha aylanadi.

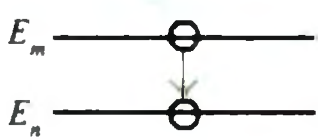
1. Atom massasi asosan yadroda to'plangan, yadrodan va uning atrofidagi elektron qobiqdan iborat.

Atom yadrosi proton va neytronlardan iborat.

Atom neytral, undagi elektronlar soni yadrodagi protonlar soniga teng.

2. **Atomning Bor modeli (planetar model). Bor postulatlari:**

a) Atom muayyan energiya mos keladigan statsionar yoki kvant holatlaridagina bo'ladi. Atom statsionar holatda yorug'lik chiqarmaydi.



b) Atom katta energiyali statsionar holatdan kichik – energiyali holatga o'tganda yorug'lik nurlanishi bo'ladi va nurlangan foton energiyasi:

$$h\nu_{\min} = E_m - E_n, \quad h = 6{,}62 \cdot 10^{-34} \text{ J} \cdot \text{s}.$$

3. Atomdagi elektronlarning impuls momenti kvantlangan, ya'ni:

$$mvr = \frac{h}{2\pi} \cdot n = n\hbar, \quad n = 1, 2, 3, \dots,$$

bu yerda m – elektron massasi; v – tezligi; r – orbita radiusi.

4. **Statsionar holatdagi atom elektronining to'la energiyasi:**

$$E = E_k + E_n = \frac{mv^2}{2} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}.$$

Elektronga ta'sir qiluvchi kuchlar: $\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$.

5. **Elektron orbitasining radiusi** $r_n = 4\pi\varepsilon_0 \cdot \frac{\hbar^2}{me^2} n^2 = a_0 n^2$ va energiyasi

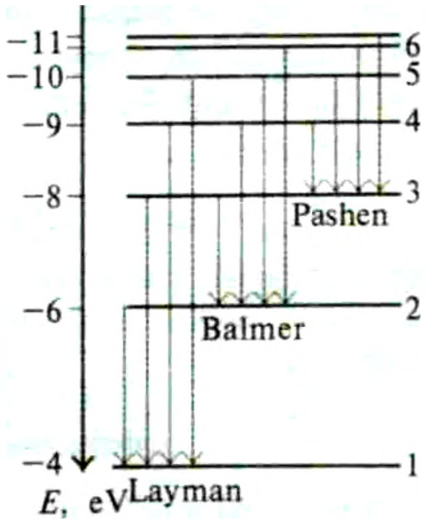
$$E_n = -\frac{1}{(4\pi\varepsilon_0)^2} \cdot \frac{me^4}{2h^2 n^2} = -\frac{R}{n^2}$$

yoki $E_n = -k^2 \cdot \frac{me^4}{2h^2 n^2}$, bu yerda

$R = \frac{1}{(4\pi\varepsilon_0)^2} \cdot \frac{me^4}{2\hbar^2} \approx 13{,}6$ eV – vodorod atomining

ionizatsiya energiyasi; $a_0 = 4\pi\varepsilon_0 \cdot \frac{\hbar^2}{me^2} \approx 0{,}529 \cdot 10^{-10}$ m –

bor radiusi – eng kichik orbita radiusi; $n = 1$, $E_1 = -R \approx$ $\approx 13{,}606$ eV – eng kichik energetik holat; n = 2, 3, 4, ...



Atom uyg'ongan holatda qisqa vaqt ($t \sim 10^{-8}$ s) bo'ladi.

Kichik energetik holatiga atom o'tganda nurlanuvchi kvant energiyasi:

$$h\nu_{min} = E_m - E_n = R \cdot \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

$n = 2$ Balmer seriyalari, $n = 3$ Pashen seriyalari va h.k. kuzatiladi.

Atomda nurning yutilish chastotasi:

$$\nu_{min} = R_R \cdot \left(\frac{1}{n^2} - \frac{1}{m^2}\right), \quad R_R = \frac{R}{h} - \text{Reynolds soni}$$

5.2. Atom yadrosi

1. Atom yadrosi proton va neytronlardan — nuklonlardan tashkil topgan.

2. Element atomi — $^A_Z Z$, bu yerda $A = Z + N$ — massa soni; Z — protonlar soni — Mendeleyev davriy sistemasidagi elementning tartib soni; $N = A - Z$ — atomdagi neytronlar soni.

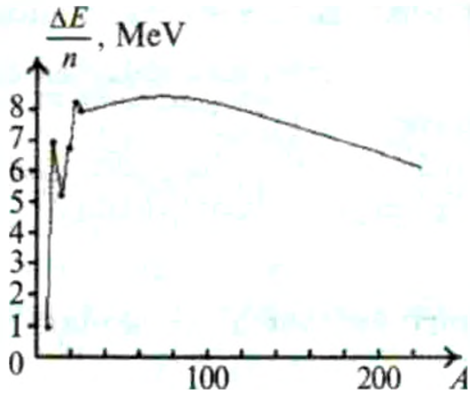
3. Protonlar soni bir xil, neytronlar soni har xil bo'lgan atomlar (yadrolar) — izotoplardir.

4. Yadrolarning radiusi $R = R_0 \cdot A^{1/3}$, $R_0 = (1{,}2-1{,}3)\cdot 10^{-13}$ sm, radius o'lchami: 1 fermi $= 1\cdot 10^{-13}$ sm $= 1\cdot 10^{-15}$ m.

5. Yadro massasi $M_{ya} < Zm_p + Nm_n$ va $\Delta m = Zm_p + Nm_n - M_{ya}$ — massa deffekti deyiladi; bu yerda m_p — proton massasi; m_n — neytron massasi. $m_p = 1{,}00728$ amb, $m_n = 1{,}00866$ amb. Bu yerda $m_0 = 1{,}66\cdot 10^{-27}$ kg atom massa birligidir, ya'ni 1 a.m.b. $= 1{,}66\cdot 10^{-27}$ kg.

6. $\Delta E_{bog'} = \Delta m \cdot c^2 = (Zm_p + Nm_n - M_{ya}) \cdot c^2$ — yadroning bog'lanish energiyasi bo'lib, yadroni nuklonlarga (proton va neytronlarga ajratish uchun zarur bo'lgan energiyadir).

7. $\dfrac{\Delta E_{bog'}}{n}$ — solishtirma bog'lanish energiyasi; bu yerda n — nuklonlar soni.



8. Yadrodagi protonlar va neytronlar orasidagi ta'sir kuchlari yadro kuchlari deyiladi.

$r < 0{,}7 \cdot 10^{-13}$ sm da $f_{ya} > 0$,

$r > 0{,}7 \cdot 10^{-13}$ sm da $f_{ya} < 0$,

$r < 2 \cdot 10^{-11}$ sm da $f_{ya} \approx 0$.

Ular: a) tortishish kuchlaridir; b) qisqa masofada mavjud; d) zarracha zaryadiga bog'liq emas.

9. **Yadro kuchlari** nuklonlarning π-mezonlar bilan almashinishi asosida mavjuddir.

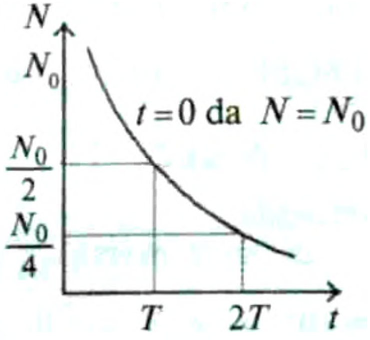
10. **Tabiiy radioaktivlik** – yadrolarning o'z-o'zidan boshqa atom yadrolariga aylanishidir (yemirilishidir):

a) Alfa (α)-yemirilish ($Z > 82$): ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$.

b) Beta (β)-yemirilish $n \rightarrow p + e^- + \bar{\nu}$, $\bar{\nu}$ – antineytrino.

d) Gamma (γ)-yemirilish.

11. **Radioaktiv yemirilish qonuni:** $N = N_0 \cdot 2^{-\frac{t}{T}}$, $\tau = 1{,}4T$; bu yerda N_0 – $t = 0$ momentdagi, N – t vaqt momentida yemirilmasdan qolgan yadrolar soni;



T – yarim yemirilish davri; $\tau = 1{,}4T$ – o'rtacha yashash vaqti. ($N = N_0 l^{-\lambda t}$ ko'rinish ham ishlatiladi bu yerda λ – yemirilish doimiysi: $T = \ln 2 / T$

12. Sun'iy radioaktivlik – bu yadro reaksiyalari natijasida vujudga keladigan radioaktivlikdir (F. Jolio-Kyuri, I. Jolio-Kyuri).

5.3. Yadro nurlanishlari va ularni qayd etish usullari

1. **Yadro nurlanishlari:**

a) α- zarrachalar, zaryadi $q = 2|e|$, massasi $m = 4$ amb, muhitda erkin yugurish yo'li λ juda qisqa (havoda bir necha sm).

b) β- zarrachalar – elektronlar, $q = e^- = 1{,}6 \cdot 10^{-19}$ C, $\lambda \sim \rho$, W ga bog'liq, havoda $10^1 - 10^3$ sm.

d) γ- zarrachalar – gamma-kvantlar, energiyasi – $h\nu$, q = 0, $m_0 = 0$. λ – havoda $\sim 10^5$ m, muhitda $\sim 10^1$ sm.

e) n- neytronlar oqimi, $q = 0$, $m_n = 1{,}00866$ amb, λ – havoda 10^5 m, muhitda $10^1 - 10^2$ sm, muhit atom yadrolari bilan reaksiyaga kirishib, yadroning nurlanishiga olib keladi.

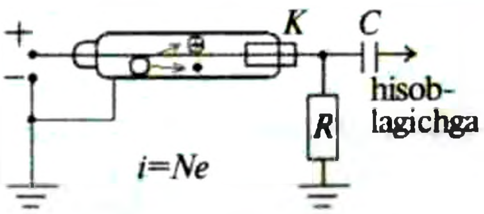
2. **Yadro nurlarining ionlovchi nurlanish dozasi** D moddaga nurlanish uzatgan energiyaning modda massasiga nisbatidir: $D = \dfrac{W}{m}$, birligi $1\,\text{Gr (grey)} = \dfrac{1\,\text{J}}{1\,\text{kg}}$, 1 rad = = 0,01 Gr, 1 R (rentgen) – 1 sm^3 quruq havoda $1\,\text{SGSE} = \dfrac{1}{3} \cdot 10^{-9}$ C zaryadi hosil qiluvchi ionlovchi nurlanish dozasidir. $1\,\text{R} = 2{,}58 \cdot 10^{-4}\,\dfrac{\text{C}}{\text{kg}}$ – ekspozitsion doza birligidir.

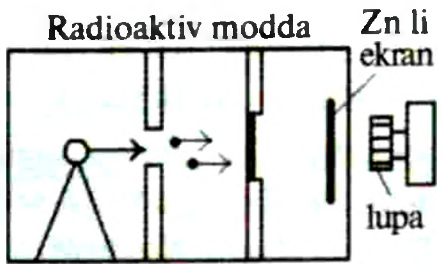
Biologik ekvivalent nurlanish dozasi birligi 1 ber = $= 10^{-2}$ J/kg. Ekspozitsion doza quvvati $N_e = \dfrac{D}{t}$ – vaqt birligida quruq havoga beriladigan 1 C/kg ekspozitsion dozadir.

Yadroviy nurlanishlarning ta'siri. Yadroviy nurlanish protonlar, β- nurlar, γ- kvantlar kabi zarralar oqimidir. Zaryadli zarralar, asosan jism atomlarining elektronlari bilan o'zaro ta'sirlashadi. Natijada, jism atomlari ionlashadi yoki uyg'ongan holatga o'tadi. γ- kvantlar yoki neytronlar jism atomlarini bevosita ionlashtirmaydi, balki jism atomi yoki atomining yadrosi bilan ta'sirlashishi tufayli zaryadli zarralar hosil bo'ladi. Bu zarralar esa jism atomlarini ionlashtiradi. Yadroviy nurlanishlar tirik to'qimalarning atom va molekulalarini ham ionlashtiradi. Natijada, sog' organizmda salbiy ta'sir ko'rsatuvchi kimyoviy birikmalar vujudga keladi. Yadroviy nurlanish ta'sirida birinchi navbatda ilik, so'ngra qon hosil bo'lish jarayoni, markaziy asab sistemasining to'qimalari, ovqat hazm qilish yo'li va jinsiy a'zolarning hujayralari shikastlanadi.

3. **Yadro nurlanish qayd qiluvchi asboblar – detektorlar**.

a) Geyger-Myuller schotchigi zaryadlangan zarrachaning gaz atomlarini ionlashiga asoslangan. Ionlashgan atomlar tok impulsini hosil qiladi. Gaz bosimi $p \sim 10^{-6}$ mm. sim. ust.





b) **Sintallatsion schotchik** zaryadlangan tez zarra kinetik energiyasining yorug'lik chaqnash energiyasiga aylanishga asoslangan.

d) **Vilson kamerasida** – o'ta to'yingan bug'li muhitda zarracha harakat qilganda suyuqlik tomchilari hosil qilib, iz-trek qoldiradi. O'zgarmas magnit maydonidagi trayektoriyasiga qarab zarrachaning parametrlari aniqlanadi.

e) **Pufakchali kamerada** – o'ta qizigan suyuqlikda zarrachalar harakatlanib pufakchalar tizimi – iz-trek qoldiradi.

f) Qalin qatlamli fotoemulsiyalar metodi – zaryadlangan zarrachalarning fotoemulsiya qatlamida harakatlanib, yashirin tasvir – iz qoldiradi va plyonka ochiltirilganda iz ravshan ko'rinadi.

5.4. Uran yadrosi bo'linishining zanjir reaksiyasi

1. **Yadro reaksiyalari** – bu zarralarning atom yadrosi bilan o'zaro ta'sirlanishi natijasida, ya'ni zarralar yoki gamma-kvantlar ajratib, yangi yadroga aylanishidir.

Birinchi bo'lib, Rezerford (1919-y.) yadro reaksiyasini amalga oshirdi:

a) ${}^{14}_{7}N + {}^{4}_{2}He \to {}^{17}_{8}O + {}^{1}_{1}H(p)$;

b) Chedvik tomonidan neytronning kashf etilishi:

$${}^{9}_{4}Be + {}^{4}_{2}He \to {}^{12}_{6}C + {}^{1}_{0}n;$$

d) tezlashtirilgan protonda reaksiya:

$${}^{7}_{3}Li + p \to {}^{4}_{2}He + {}^{4}_{2}He;$$

e) ${}^{27}_{13}Al + {}^{4}_{2}He \to {}^{30}_{15}P + {}^{1}_{0}n$, ${}^{30}_{15}P \to {}^{30}_{14}Si + {}^{0}_{+1}e$ (pozitronning olinishi, F. Jolio-Kyuri 1924-y.).

2. **Yadro reaksiyalari vaqtida energiya ajralishi** ($\Delta m < 0$) yoki yutilishi ($\Delta m > 0$) mumkin va bu energiya $\Delta E = \Delta m \cdot c^2$, bu yerda $\Delta m = Zm_p + Nm_n - M_{ya}$ – massa de-

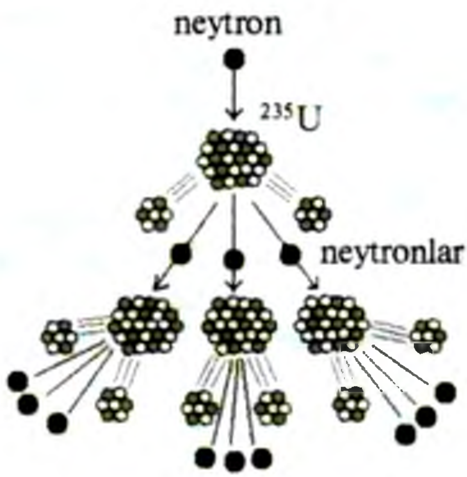
fekti va m_p – protonning, m_n – neytronning, M_{ya} – yadroning tinchlikdagi massalari.

3. **Yadro reaksiyalari uchun saqlanish qonunlari:**

$$^{A1}_{Z1}\mathrm{El} + ^{A2}_{Z2}\mathrm{El} \rightarrow ^{A3}_{Z3}\mathrm{El} + ^{A4}_{Z4}\mathrm{El},\ Z_1 + Z_2 = Z_3 + Z_4,$$

$$A_1 + A_2 = A_3 + A_4.$$

4. **Uran yadrosi bo'linishining zanjir reaksiyasi.**



Reaksiya o'zidan keyin xuddi shunday reaksiyani amalga oshirsa, bunday reaksiya zanjir reaksiya deyiladi.

Uran yadrosi neytron ta'sirida bo'linganda, yana 2 yoki 3 ta neytron hosil bo'ladi. Ketma-ket bo'linishlarda hosil bo'lgan neytronlar sonining nisbati neytron kuchayish koeffitsiyenti k deyiladi.

$k = 1$ – doimiy,

$k < 1$ – reaksiya so'nadi,

$k > 1$ da ortadi, unda portlash zanjir reaksiyasining borish shartlari:

a) neytronlarning tezligi yetarlicha bo'lishi kerak;

b) neytronni yutuvchi aralashmalar bo'lishi kerak emas;

d) zanjir reaksiyasi uchun yetarli miqdorda modda – kritik massali modda bo'lishi kerak:

$$^{235}_{92}\mathrm{U} + ^{1}_{0}n \rightarrow ^{139}_{56}\mathrm{Ba} + ^{95}_{36}\mathrm{Kr} + 2^{1}_{0}n + 200\ \mathrm{MeV},$$

$$^{239}_{92}\mathrm{U} \rightarrow ^{239}_{93}\mathrm{Np} + ^{0}_{-1}e,\quad ^{239}_{93}\mathrm{Np} \rightarrow ^{239}_{94}\mathrm{Pu} + ^{0}_{-1}e.$$

5. **Yadro reaktori** – yadro reaksiyasini boshqarib, uning energiyasini elektr (yoki issiqlik) energiyasiga aylantirib beruvchi qurilmadir.

Reaktorning asosiy elementlari:

a) yadro yoqilg'i $\left({}^{235}_{92}U, {}^{238}_{92}U, {}^{239}_{94}Pu\right)$;

b) neytronni sekinlashtiruvchi (og'ir suv, grafit);

d) issiqlik tashuvchi modda (suv, suyuq natriy);

e) reaksiyani boshqaruvchi qurilma materiali (kadmiy, bor, gafniy);

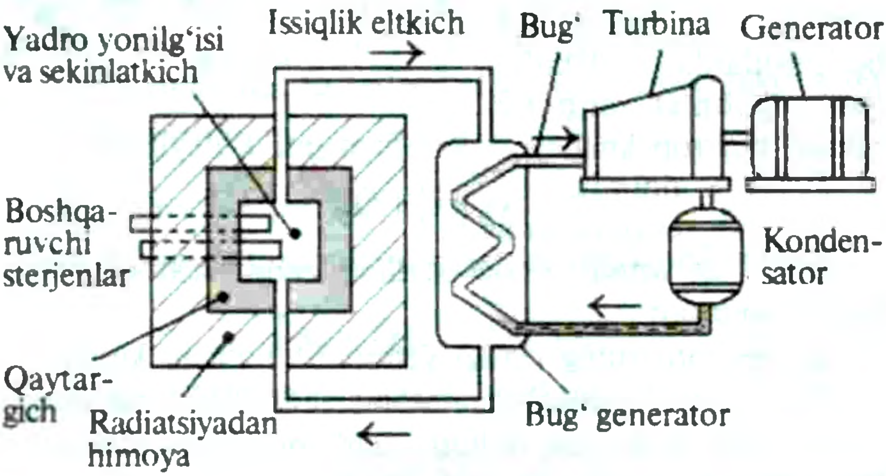
f) himoya (beton qobiq, temir);

6. **Termoyadro reaksiyasi** – yengil yadrolarning birikib, og'irroq yadrolarning hosil qilishidir. Bu reaksiyalar yuqori temperaturalarda (10^8 K) ro'y beradi. Masalan:

$$ {}^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + 17,7 \text{ meV}. $$

Deyteriy va tritiy yadrolarning qo'shilib geliy yadrosini hosil qilganda ajraladigan energiya har bir nuklonga 3,5 MeV to'g'ri keladi.

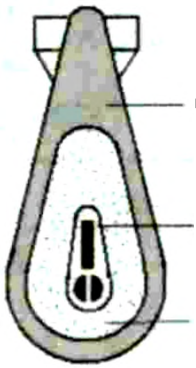
Atom bomba. Bo'linish jarayonida vujudga keladigan



neytronlarning reaksiyada qatnashmay chiqib ketishini kamaytirish (ya'ni $K_k$ning qiymatini oshirish) uchun bo'linuvchi modda massasini kattaroq qilib olish kerak. Bo'linuvchi moddaning biror m_k yoki undan kattaroq massasida zanjir reaksiya amalga oshishiga sharoit yaratiladi, m_k – kritik massa deb ataladi.

$m < m_k$ da esa $K_k < 1$ bo'lgani uchun zanjir reaksiya amalga oshmaydi. Shuning uchun atom bombada bo'linuvchi modda ikki yoki ko'proq bo'laklar tarzida tayyorlanadi. Bo'laklarning umumiy massasi kritik massadan katta, har bo'lak massasi esa kritik massadan kichik. Shu sababli zanjir reaksiya bo'laklarda rivojlanmaydi. Portlovchi qurilma portlaganida mazkur bo'laklar birlashadi va boshqarilmaydigan tarzda zanjir reaksiya amalga oshadi.

Termoyadroviy bomba. Termoyadroviy reaksiyada qatnashadigan modda (rasmda $H^2 + H^3$ deb belgilangan) ichida atom bomba portlatilganda g'oyat qisqa vaqt davomida temperatura 10^7 K ga yetib, deyteriy va tritiy birikadi va energiya ajralib chiqishi yanada kuchliroq portlash tarzida namoyon bo'ladi. Bayon etilgan prinsipda ishlaydigan qurolda vodorod izotoplari qo'llanilganligi sababli uni vodorod bomba deb ham ataladi.



Neytron bomba deb ataluvchi qurolda esa yadrolar sintezi amalga oshishi uchun talab qilinadigan sharoit atom bombani portlatish yo'li bilan emas, balki boshqa usullar yordamida vujudga keltiriladi. Mazkur qurolda yadrolar sintezi tufayli ajraladigan energiyaning portlash jarayonida ajraladigan umumiy energiyaga nisbati 0,9–0,95 ga teng bo'ladi. Ajraladigan energiyaning asosiy qismi (~80%) neytronlarning energiyasi sifatida namoyon bo'ladi (qurolni neytron bomba deb atalishining sababi ham shunda). Shuning uchun neytron bomba portlaganda vujudga keladigan zarb to'lqin anchagina kuchsiz, lekin yadroviy nurlanish nihoyat kuchli bo'ladi.

5.5. Elementar zarrachalar

Elementar zarrachalar – bo'linmaydigan birlamchi zarrachalardir va ulardan barcha materiya tashkil topgan.

Foton, elektron, proton va neytrondan boshqa zarrachalar bir-biriga aylanib turadi.

1. Elementar zarrachalar massasi, elektr zaryadi, spini va yashash vaqti bilan xarakterlanadi.

Spin – zarraning aylanma harakatidagi mexanik momenti bo'lib, $h = \frac{h}{2\overline{u}}$ birliklarida o'lchanadi.

Elementar zarrachalar jadvali.

Zarrachalarning nomi		Zarracha	Antizarracha	Elektron massasi hisobidagi massa	Elektr zaryadi	Yashash vaqti, s
Foton		γ	γ	0	0	Barqaror
Leptonlar	Elektroniy neytrino	ν_e	$\bar{\nu}_e$	0	0	Barqaror
	Myuoniy neytrino	ν_μ	$\bar{\nu}_\mu$	0	0	Barqaror
	Tau neytrino	ν_τ	$\bar{\nu}_\tau$	0	0	Barqaror
	Elektron	e^-	e^+	1	−1	Barqaror
	Myuon	μ^-	μ^+	207	−1	$2{,}2 \cdot 10^{-6}$
	Tau-lepton	τ^-	τ^+	348	−1	$1{,}46 \cdot 10^{-12}$

Mezonlar		Pi-mezonlar (pionlar)	π^0	$\tilde{\pi}^0$	264,1	0	$1{,}83\cdot10^{-16}$
			π^+	π^-	273,1	1	$2{,}6\cdot10^{-8}$
		Ka-mezonlar (kaonlar)	K^+	K^-	966,4	0	$1{,}2\cdot10^{-8}$
			K^0	K^0	971,1	0	$K_S^0 - 8{,}9\cdot10^{-11}$ $K_L^0 - 5{,}2\cdot10^{-8}$
		Eta-nol-mezonlar	η^0	η^0	1074	0	$2{,}4\cdot10^{-19}$
Barionlar	Nuklonlar	Proton	p	$\tilde{p}$	1836,1	1	Barqaror
		Neytron	n	$\tilde{n}$	1838,6	0	10^3
	Giperonlar	Lambda-giperon	Λ^0	$\tilde{\Lambda}^0$	2183,1	0	$2{,}63\cdot10^{-10}$
		Sigma-giperon	Σ^+	$\tilde{\Sigma}^+$	2327,6	1	$8\cdot10^{-11}$
			Σ^0	$\tilde{\Sigma}^0$	2333,6	0	$5{,}8\cdot10^{-20}$
			Σ^-	Σ	2342,1	−1	$1{,}48\cdot10^{-10}$
		Ksi-giperon	Ξ^0	$\tilde{\Xi}^0$	2572,8	0	$2{,}9\cdot10^{-10}$
			Ξ^-	$\tilde{\Xi}^-$	2583,6	1	$1{,}64\cdot10^{-10}$
		Omega-minus-giperon	Ω^-	$\tilde{\Omega}^-$	3273	−1	$8{,}2\cdot10^{-11}$

3. **Antizarra** – zarraning massasiga teng, elektr zaryadi (zaryadlangan zarrachalar uchun) son jihatdan teng va qarama-qarshi ishorali zarrachadir.

Foton va pi-nol-mezon kabi zaryadlanmagan zarralarda zarra va antizarraning fizik xossalari bir xil va shuning uchun ayni bir xil zarradir.

4. **Kvarklar** – eng kichik (zaryadi $+\frac{2}{3}e$ bo'lgan *u*-kvark va $-\frac{1}{3}e$ bo'lgan *d* va *s*-kvarklar) elementar

zarrachalardir. Proton 2 ta *u* va 1 ta *d* kvarkdan tuzilgan. Bir barion 3 ta kvarkdan, antibarion, 3 ta antikvarkdan, mezonlar kvark va antikvark juftlaridan iborat va h. Ularning yashash vaqti $\tau \sim 10^{-13}$ s.

5.6. Zarralarning to'lqin xossalari

1. Zarralar oqimi ham korpuskulyar, ham to'lqin xossalariga ega: elektronlar, atomlar, neytron va protonlar oqimida difraksiya va interferensiya hodisalari kuzatiladi.

2. $E = h\nu = mc^2$ energiyali fotonlar oqimi – yorug'likning to'lqin uzunligi $\lambda = \frac{c}{\nu} = \frac{h}{mc}$, chunki $\nu = \frac{mc^2}{h}$.

3. υ tezlik bilan harakatlanayotgan m massali istalgan zarracha oqimining to'lqin uzunligi $\lambda = \frac{h}{m\upsilon}$ (De Broyl to'lqin uzunligi deyiladi).

4. De Broyl gipotezasi va Bor atomi. Vodorod atomida ruxsat etilgan birinchi doiraviy orbitada harakatlanuvchi elektronning De Broyl to'lqin uzunligi $\lambda = \frac{h}{m\upsilon}$ va $mV_n r_n = n\hbar = \hbar$ dan ($\hbar = \frac{h}{2\pi}$), $\lambda_1 = 2\pi r_1$, *n*-orbita uchun $n\lambda = 2\pi r_n$.

5.7. Zarrachalarning o'zaro ta'sir turlari

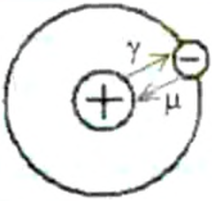
Barcha zarrachalar o'zaro ta'sirlashadi. O'zaro ta'sirning 4 ta fundamental turlari mavjud:

a) gravitatsion;
b) elektromagnit;
d) kuchli;
e) kuchsiz.

1. **Gravitatsion o'zaro ta'sir kuchlari** butun olam tortishish qonuni ko'rinishida namoyon bo'ladi. Gravitatsion o'zaro ta'sir kuchlari «graviton» degan zarrachalar yordamida uzatiladi. U zarracha bugungi kungacha topilmagan.

2. Zaryadlangan zarrachalar orasidagi o'zaro ta'sir **elektromagnit** bo'lib, ular fotonlar yordamida amalga oshadi. Zaryadlangan zarrachalar, shu jumladan, yadro va elektronlar o'zaro elektromagnit maydoni orqali ta'sirlashadi va uning kvanti foton hisoblanadi.

Foton



μ-mezon

3. **Kuchli o'zaro ta'sir** mezonlar va barionlar orasida mavjud. Proton bilan neytron orasidagi o'zaro ta'sir yadro maydonining kvanti – π-mezonlar orqali amalga oshadi. Kuchli o'zaro ta'sirlashuvchi mezonlar va barionlar kvarklardan tashkil topgan. Kvarklar proton va neytronlar tarkibida ham bor, lekin hali erkin holda topilmagan. Kvarklar orasidagi kuchli o'zaro ta'sir glyuonlar orqali amalga oshadi.

π-mezon

glyuon

4. **Kuchsiz o'zaro ta'sir** fotondan tashqari barcha zarrachalar uchun o'rinlidir. Kuchsiz o'zaro ta'sir leptonlar va kvarklarning o'zaro ta'siri uchun ham tegishli. Kvarklar va leptonlar $(\nu, e^{\pm}, \mu^{\pm}, \tau^{\pm})$ orasidagi ta'sir W^{-}, W^{+}, Z^{0} bozonlar orqali amalga oshiriladi.

bozonlar

Bugungi kunda 250 dan ortiq zarracha va antizarrachalar mavjud. Bulardan 80 dan ortig'i stabil bo'lib, yashash vaqti 10^{-17} s dan katta va 200 dan ortig'i qisqa muddatli rezonans muvaqqat yashovchi bo'lib, yashash vaqti ~10^{-23} s.

O‘z-o‘zini sinash uchun testlar

1. Oniy tezlik deb qanday tezlikka aytiladi?

A. Trayektoriyaning ma'lum nuqtasidagi yoki berilgan vaqt momentidagi tezlik oniy tezlik deyiladi.

B. Harakat boshidagi tezlik oniy tezlik deyiladi.

C. Tekis tezlanuvchan harakatda boshlang‘ich tezlik oniy tezlik deyiladi.

D. Tekis harakatda trayektoriyaning barcha nuqtalaridagi tezlik oniy tezlik bo‘ladi.

2. Sanoq jism va unga biriktiriladigan koordinatalar sistemasi hamda vaqt sanog‘i birgalikda sanoq sistemasi deyiladi. Qanday sanoq sistemalarini bilasiz?

A. Inersial sanoq sistemasi – bir-biriga nisbatan to‘g‘ri chiziqli tekis harakat qiladi yoki tinch holatda bo‘ladi;

Noinersial sanoq sistemasi – bir-biriga nisbatan tezlanish bilan harakat qiladi.

B. Nuqtaning vaziyatini koordinatalar (sonlar)da ifodalash uchun koordinatalar sistemasi;

Jismning harakati boshqa bir jismga nisbatan o‘rganiladigan sanoq sistemasi.

C. Sanoq jism va unga biriktiriladigan koordinatalar sistemasi;

To‘g‘ri chiziqli harakatda ko‘chish (yo‘l) bilan koordinata orasidagi bog‘lanish sanoq sistemasi deyiladi.

D. Koordinatalar sistemasi hamda vaqt sanog‘i birgalikda sanoq sistemasi deyiladi;

Inersial sanoq sistemasi.

3. Ko‘chish deb nimaga aytiladi?

A. Trayektoriyaning uzunligiga aytiladi.

B. Vaqt birligida bosib o‘tilgan yo‘l ko‘chish deyiladi.

C. Jismning boshlang‘ich va oxirgi vaziyatini tutashtiruvchi yo‘nalishli kesma ko‘chish deyiladi.

D. Hamma javob to‘g‘ri.

4. To'g'ri chiziqli tekis o'zgaruvchan harakat deb qanday harakatga aytiladi?

A. Trayektoriyasi to'g'ri chiziqdan iborat bo'lib, tezligi bir xil vaqt intervallarida bir xil kattalikka o'zgaradigan harakat to'g'ri chiziqli tekis o'zgaruvchan harakat deyiladi.

B. Tezlikning vaqt birligida o'zgarishi to'g'ri chiziqli tekis o'zgaruvchan harakat deyiladi.

C. Tezligi bir xil vaqt intervallarida bir xil kattalikka o'zgaradigan harakat to'g'ri chiziqli tekis o'zgaruvchan harakat deyiladi.

D. Trayektoriyasi aylanadan iborat bo'lib, tezlanishi bir xil vaqt intervallarida bir xil kattalikka o'zgaradigan harakat tekis harakat deyiladi.

5. Nyutonning I qonunini ta'riflab bering.

A. Istalgan sanoq sistemasida jismga boshqa kuch ta'sir etmasa, jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlaydi.

B. Jismga boshqa jism ta'sir etmasa, jism o'zining tinch yoki to'g'ri chiziqli tekis harakatini saqlaydi.

C. Inersial sanoq sistemalarida jismga boshqa jism ta'sir etmasa yoki ularning ta'siri o'zaro kompensatsiyalansa, jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlaydi.

D. Tashqi ta'sir bo'lmaganda jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlash xossasiga inersiya deyiladi.

6. Nyutonning II qonunini ta'riflab bering.

A. Jismga qo'yilgan kuch jismning tezlanishini aniqlaydi (belgilaydi);

B. Tezlanishning yo'nalishi kuch yo'nalishi bilan bir xil;

C. Jismga ta'sir etuvchi kuch massani tezlanishga nisbatiga teng: $F = m / a$.

D. Jismga ta'sir etuvchi kuch uning massasi bilan shu kuch ta'sirida olgan tezlanishning ko'paytmasiga teng:

$$\vec{F} = m \cdot \vec{a}\,.$$

7. Nyutonning III qonuni qanday ta'riflanadi?

A. Jismlarning bir-biriga (o'zaro) ta'sir kuchlari o'zaro teng, qarama-qarshi yo'nalgan va bir to'g'ri chiziqda yotadi.

B. Jismlarning o'zaro ta'sirlarining tengligi barcha hollarida bajariladi.

C. O'zaro ta'sir kuchlarining tabiati bir xil.

D. Agar jismga bir necha kuch ta'sir qilsa, ularning teng ta'sir etuvchisi nolga teng.

8. Impuls saqlanish qonunini tariflab bering.

A. Impuls saqlanish qonuni yopiq (izolatsiyalangan) sistemada jismlarning impulslarining vektor yig'indisi ular o'zaro ta'sirlashganda ham doimiy qoladi.

B. Har qanday sistemada jismlarning impulslarining vektor yig'indisi ular o'zaro ta'sirlashganda doimo nolga teng bo'ladi.

C. Noinersial sistemada jismlarning, impulslarining vektor yig'indisi ular o'zaro ta'sirlashganda ham doimiy qolmaydi.

D. Inersial (izolatsiyalangan) sistemada jismlarning impulslarining yig'indisi doimiy bo'lmaydi.

9. Ishning to'g'ri va to'liq ta'rifini va formulasini ko'rsating.

A. Jismga ta'sir etuvchi kuchni, jism ko'chishi, kuch va ko'chish vektorlari orasidagi burchak kosinusining ko'paytmasiga ish deyiladi – $A = F \cdot r \cdot \cos\alpha$ va $A = \left(\vec{F} \cdot \vec{r}\right)$

B. Kuch va ko'chish vektorlarining vektor ko'paytmasiga ish deyiladi – $A = \left[\vec{F} \cdot \vec{r}\right]$.

C. Jismga ta'sir etuvchi kuchni, jism ko'chishi, kuch va ko'chish vektorlari orasidagi burchak sinusining ko'paytmasiga ish deyiladi: $A = F \cdot r \cdot \sin\alpha$.

D. Kuch va ko'chish vektorlarining nisbatiga ish deyiladi: $A = \left(\vec{F}/\vec{r}\right)$.

10. Potensial energiyaning to'g'ri va to'liq ta'rifini va formulasini ko'rsating.

A. Jismning harakati tufayli ega bo'lgan energiyasiga potensial energiya deyiladi. $E_p = \dfrac{m\upsilon^2}{2}$.

B. Og'irlik kuchi ta'sir qilayotgan jismning energiyasiga potensial energiya deyiladi.

C. Tortishish kuchlari ta'sir qilayotgan jismning energiyasiga potensial energiya deyiladi.

D. Jismlarning o'zaro ta'siri natijasida ega bo'lgan energiyasiga potensial energiya deyiladi: $E_p = mgh$.

11. Paskal qonunining to'g'ri va to'liq ta'rifini ko'rsating.

A. Suyuqlik yoki gazga berilgan bosim barcha yo'nalishda bir xil va o'zgarishsiz uzatiladi: $\vec{p} = \text{const}$.

B. Suyuqlik yoki gazga berilgan bosim o'zgarmaydi: $\vec{p} = \text{const}$.

C. Suyuqlik yoki gazga berilgan bosim barcha yo'nalishda har xil bo'ladi: $p_x \neq p_y \neq p_z$

D. Suyuqlik yoki gazga berilgan bosim bir xil va yuqoriga yo'nalgan: $\vec{p} = \text{const}$.

12. Bernulli tenglamasini ko'rsating:

A. $p_1 + \rho g h_1 + \dfrac{\rho\upsilon_1^2}{2} = p_2 + \rho g h_2 + \dfrac{\rho\upsilon_2^2}{2} = \text{const}$.

B. $S_1\upsilon_1 = S_2\upsilon_1$.

C. $\upsilon = \sqrt{2g(h_2 - h_1)}$.

D. $\rho_1 S_1 \upsilon_1 = \rho_2 S_2 \bar{\upsilon}_2$.

13. Mexanikaning oltin qoidasi qanday ta'riflanadi?

A. Jism yoki jismlar sistemasining og'irlik (massa) markazi – uning barcha qismlariga ta'sir etuvchi og'irlik kuchlarining teng ta'sir etuvchisi qo'yilgan nuqtada bo'ladi.

B. Kuchdan necha marta yutilsa, yo'ldan shuncha marta yutqaziladi va aksincha.

C. Jismlar sistemasining og'irlik (massa) markazidan o'tgan o'qqa nisbatan uning barcha qismlarining og'irlik kuchlarining momentlarining yig'indisi nolga teng.

D. Kuchdan necha marta yutilsa, yo'ldan shuncha marta yutiladi.

14. Molekular-kinetik nazariyaning asosiy tenglamasini ko'rsating.

A. $p = k \cdot T$.

B. $p = \frac{1}{3} \rho \bar{\upsilon}^2$.

C. $E_k = \frac{m\bar{\upsilon}^2}{2}$.

D. $p = \frac{2}{3} R \cdot \frac{m\bar{\upsilon}^2}{2}$ yoki $p = \frac{2}{3} n \bar{E}_k$.

15. Ideal gaz holat tenglamasini va ta'rifini ko'rsating.

A. $p = RT$ – Gaz xarakterlaydigan parametrlari: p va T orasidagi bog'lanishni ifodalaydigan tenglamaga ideal gaz holat tenglamasi deb ataladi.

B. $pV = \frac{M}{\mu} RT$ – Gaz yoki gazlar sistemasini xarakterlaydigan parametrlari: p, V va T orasidagi bog'lanishni ifodalaydigan tenglamaga gaz holat tenglamasi deb ataladi.

C. $p = nkT$ — Gaz molekulalarining konsentratsiyasi va bosimi orasidagi bog'lanishini ifodalovchi tenglamaga gaz holat tenglamasi deb ataladi.

D. $R = k \cdot N_A$ — 1 mol gaz uchun Mendeleyev-Klapeyron holat tenglamasi – ideal gaz holat tenglamasi deb ataladi.

16. Termodinamikaning I qonunining to'g'ri ta'rifini ko'rsating.

A. Moddani tashkil qilgan barcha zarrachalarining kinetik va potensial energiyalarining yig'indisi moddaning ichki energiyasi bo'lib, u termodinamikaning I qonuni deb ataladi.

B. Ideal gazning ichki energiyasini o'zgarishi haqidagi qonun termodinamikaning I qonuni deb ataladi.

C. Termodinamikaning I qonuni: sistemaga berilgan issiqlik miqdori uning ichki energiyasining o'zgarishi ΔU bilan uning bajargan ishi A ning yig'indisiga teng: $Q = \Delta U + A$.

D. Termodinamikaning I qonuni issiqlik jarayonlari uchun energiyaning saqlanish qonunini ifodalaydi.

17. Kondensatorlarni parallel va ketma-ket ulaganda umumiy sig'imni hisoblash formulasini ko'rsating.

A. $C_{um} = C_1 + C_2 + C_3 + \ldots + C_n$ va

$C = C_1 \cdot C_2 \cdot C_3 \ldots \cdot C_n$.

B. $\frac{1}{C_{um}} = \frac{1}{C_1} - \frac{1}{C_2} - \ldots - \frac{1}{C_n}$ va

$C_{um} = C_1 - C_2 - C_3 - \ldots - C_n$.

C. $C_{um} = C_1 + C_2 + C_3 + \ldots + C_n$ va

$$\frac{1}{C_{um}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots + \frac{1}{C_n}.$$

D. $C_{um} = C_1 + C_2 - C_3 + C_4 - ... + C_n$,

$C_{um} = C_1 \cdot C_2 \cdot C_3 ... \cdot C_n$.

18. Zanjirning bir qismi uchun Om qonunini ifodalovchi formulani ko'rsating.

A. $I = \frac{U}{R}$.

B. $J = \frac{I}{S} \cdot R$.

C. $I \approx U \cdot R$.

D. $I = \frac{\Delta q}{\Delta t}$.

19. Butun zanjir uchun Om qonunini ifodalovchi formulani ko'rsating.

A. $I = \frac{\varepsilon}{R+r}$.

B. $I = \frac{U+\varepsilon}{R+r}$.

C. $I = \frac{U-\varepsilon}{R+r}$.

D. $U_k = E + I \cdot r$.

20. Ushbu qoida qaysi qonunga tegishli «chap qo'l shunday joylashtiriladiki, unda ochilgan to'rtta barmoq tok yo'nalishi bilan mos tushsin. Magnit maydon induksiya chiziqlari esa kaftga tik yo'nalsin va unda to'g'ri burchakka ochilgan bosh barmoq Amper kuchi yo'nalishini ko'rsatadi»?

A. Lorens qonuniga.
B. Lens qonuniga.
C. Amper qonuniga.
D. Faradey qonuniga.

21. Qanday mayatnik matematik mayatnik deb ataladi?

A. Vaznsiz, cho'zilmaydigan ipga osilgan sharchadan tashkil topgan va muvozanat vaziyati atrofida davriy tebranma harakat qiluvchi sistemaga matematik mayatnik deyiladi.

B. Og'irlik kuchining tashkil etuvchisi ta'sirida tebranadigan mayatnikka matematik mayatnik deyiladi.

C. Ixtiyoriy nuqtasidan osilgan qattiq jismdan tashkil topgan va muvozanat vaziyati atrofida davriy tebranma harakat qiluvchi sistemaga matematik mayatnik deyiladi.

D. O'lchami ipning uzunligiga teng bo'lib, cho'zilmaydigan ipga osilgan jismning muvozanat vaziyati atrofida davriy tebranma harakat qiluvchi sistemaga matematik mayatnik deyiladi.

22. L — induktiv g'altak va C — kondensatordan tashkil topgan berk zanjirdan iborat bo'lgan tebranish konturidagi tebranishlar davri formulasini ko'rsating:

A. $T = 2\pi\sqrt{LC}$.

B. $T = 2\pi\sqrt{\frac{1}{LC}}$.

C. $T = \frac{1}{2\pi}\sqrt{LC}$.

D. $T = 2\pi\sqrt{\frac{1}{C}}$.

23. Agar muz parchasini 0°C li xonaga olib kirib qo'yilsa, muz eriydimi?

A. Ha, muz eriydi, chunki uning harorati xona haroratidan kichik.

B. Yo'q, agar muz mato bilan o'rab qo'yilsa — eriydi;

C. Xonada kuchli yorug'lik nurlanishi bo'lmasa, muz erimaydi.

D. Yo'q, muz erimaydi, chunki uni 0°C gacha isitishdan tashqari $Q = \lambda$ m issiqlik miqdori berilishi kerak.

24. Qarshiligi 10 Ω bo'lgan elektr lampa va 5 Ω qarshilikli reostat bilan ketma-ket ulanib, 4,5 V kuchlanishli tok manbayiga ulangan. Bu zanjirdagi tok kuchi qancha?

A. 0,3 A.
B. 0,45 A.
C. 0,22 A.
D. 0,9 A.

25. Quyosh energiyasining Yerga uzatilishi qanday yo'l bilan amalga oshadi?

A. Konveksiya yo'li bilan.
B. Issiqlik o'tkazuvchanlik yo'li bilan nurlanish.
C. Asosan nurlanish yo'li bilan.
D. Konveksiya va issiqlik o'tkazuvchanlik yo'li bilan.

26. Nima uchun Yerdan turib osmonga qarasak, u zangori rangda, Oydan qaraganda esa qora bo'lib ko'rinadi?

A. Chunki Yerdan turib osmonga qarasak, yorug'lik Yerning atmosfera qatlamida sochilishi sababli zangori rangda, Oydan qaraganda esa qora bo'lib ko'rinadi.

B. Yerdan turib osmonga qarasak, u ham Oydan qaragandagi kabi yorug'lik har xil yutilgani uchun.

C. Yerdan turib osmonga qaraganda ham, Oydan qaraganda ham yorug'lik har xilda atmosferadan qaytgani uchun.

D. Chunki, Yer atmosferasi yorug'lik to'lqinini yutadi, oy atmosferasi esa sochib yuboradi.

27. Yashil rangli shisha idishga qizil siyoh quyilgan. Siyohga yashil shisha orqali qaralsa, u qanday rangda ko'rinadi?

A. Qizil siyoh quyilgan idishga yashil shisha orqali qaralsa, u yashil rangda ko'rinadi.

B. Yashil rangli shisha faqat yashil rangli yorug'likni o'tkazadi, qizil siyoh esa uni yutadi, shuning uchun u qora bo'lib ko'rinadi.

C. Qizil siyohga yashil shisha orqali qaralsa, u ko'k rangda ko'rinadi.

D. Yashil rangli shisha idishdagi siyohga yashil shisha orqali qaralsa, u qizil bo'lib ko'rinadi.

28. Nima uchun omborlarda saqlanadigan don mahsulotlarini infraqizil nurlar bilan nurlaganda zararli hasharotlar nobud bo'ladi, ammo donga zarar yetmaydi?

A. Omborlarda saqlanadigan don mahsulotlarini infraqizil nurlar bilan nurlaganda hasharotlar uyquga ketadi.

B. Omborlarda saqlanadigan don mahsulotlarini infraqizil nurlar bilan nurlaganda hasharotlar qo'rqib ketib, omborxonani tark etadilar.

C. Don mahsulotlarida uchraydigan zararli hasharot (qo'ng'iz)larning aksariyati qora bo'lgani uchun ular infraqizil nurlarni yutib, natijada halok bo'ladi. Infraqizil nurlar donga ta'sir qilmaydi.

D. Omborlarda saqlanadigan don mahsulotlarini infraqizil nurlar bilan nurlaganda uning ichidagi barcha hasharotlar kuyib ketadi, don mahsulotlari esa zararlanmaydi.

29. Nima uchun rentgenolog shifokorlar ish vaqtida qo'rg'oshin tuzi shimdirilgan qo'lqop, fartuk va ko'zoynakdan foydalanadalar?

A. Rentgenolog shifokorlar ish vaqtida shunday uniformadan foydalanishlari shart.

B. Rentgenolog shifokorlar ish vaqtida qo'rg'oshin tuzi shimdirilgan qo'lqop, fartuk va ko'zoynakdan foydalansalar, bu kiyimlar rentgen nurlarini deyarli o'tkazmaydi.

C. Rentgenolog shifokorlar bemorlardan ajralib turish uchun ish vaqtida qo'rg'oshin tuzi shimdirilgan qo'lqop, fartuk va ko'zoynakdan taqib oladilar.

D. Chunki qo'rg'oshin rentgen nurlarini yutadi.

30. Quvvatlari bir xil bo'lgan qizil va yashil lampalardan qaysi biri ko'proq yorug'lik tarqatadi?

A. Har ikkala lampa xiralashgan bo'ladi.
B. Har ikkala lampa bir xil yorug'lik tarqatadi.
C. Qizil lampa.
D. Yashil lampa.

31. $T = \frac{\pi}{2}\sqrt{LC}$ formuladagi $\frac{\pi}{2}$ ning fizik ma'nosini ayting.

A. Konturda chorak, ya'ni $\frac{T}{4}$ davr tebranish ro'y berishini bildiradi.

B. $T = \frac{\pi}{2}\sqrt{LC}$ formuladagi $\frac{\pi}{2}$ 180° burchakni bildiradi.

C. Konturdagi tebranishlarning $\frac{\pi}{4}$ fazaga siljishini anglatadi.

D. T davrning yarmini anglatadi.

32. Yuqori kuchlanishli liniya simi uzilib tushgan zonada qolgan odam bu xavfli zonadan qanday chiqib ketishi mumkin?

A. Yuqori kuchlanishli sim uzilib tushgan zonada simdan 15–20 m radiusli aylana ichida simdagi kuchlanish qiymatiga qarab taxminan 2000 V/m elektr maydon kuchlanganligi hosil bo'ladi. Bu zonada qolgan odam u yerdan mayda qadam tashlab yoki bir oyoqda sakrab-sakrab chiqib ketishi mumkin.

B. Yuqori kuchlanishli liniya simi uzilib tushgan zonada qolgan odam katta-katta qadam bilan chiqib ketishi kerak;

C. Yuqori kuchlanishli liniya simini yerdan ko'tarib qo'yish kerak.

D. Yuqori kuchlanishli liniya simi uzilib tushgan zonada qolgan odamni qutqarib bo'lmaydi.

33. Parijdagi Eyfel minorasining balandligi qancha va qanday o'zgarib turadi?

A. Eyfel minorasining balandligi ma'lumotlarga ko'ra 300 m ga teng va u o'zgarmaydi.

B. Eyfel minorasining balandligi atrof-muhit haroratiga bog'liq ravishda o'zgarib turadi.

C. Eyfel minorasining balandligi 300 m ga teng bo'lib, bu qiymat haroratga bog'liq ravishda ± 120 mm ga o'zgarib turadi.

D. Eyfel minorasining balandligi 300 m ga teng va uning uzunligi ± 120 mm ga o'zgaradi, uning uchi shamolga bog'liq ravishda gorizontal yo'nalishda 2–3 m ga chayqalib turadi.

34. Quyida keltirilgan formulalarning qaysi biri tekis tezlanuvchan harakatda bosib o'tilgan yo'l formulasi hisoblanadi?

A. $\vartheta = \frac{s}{t}$.

B. $F = F \cdot s$.

C. $s = \upsilon \cdot t$

D. $s = \upsilon_0 \cdot t + \frac{at^2}{2}$.

35. Nima uchun bo'r doskada iz qoldiradi?

A. Bo'r changini doska molekulalari o'ziga tortib oladi.

B. Bo'r changlari zaryadlanib doskaga yopishib qoladi.

C. Doska sirti yuzasining notekisligi natijasida bo'r zarralari yopishib, doskada iz qoldiradi.

D. Doska molekulalari ishqalanish kuchlari ta'sirida zaryadlanib, bo'r molekulalarini o'ziga tortib oladi.

36. Nima uchun oshqozonni rentgenda ko'rish uchun bemorga bariy karbonat tuzi ichiriladi?

A. Bariy karbonat tuzlari rentgen nurini yaxshi yutadi;

B. Bariy karbonat tuzlari rentgen nurini yaxshi qaytaradi;

C. Bariy karbonat tuzlari oshqozon devorlarini yaxshi ho'llaydi;

D. Bariy karbonat tuzlari oshqozon devorlarini ho'llash-ho'llamasligiga qarab, rentgen nurini qaytaradi va oshqozon devorlarining sog'lomlik darajasi baholanadi;

TESTLARNING TO'G'RI JAVOBLARI

1.A.	2.A.	3.C.	4.A.	5.C.	6.D.	7.A.	8.A.	9.A.	10.D.
11.A.	12.A.	13.B.	14.D.	15.B.	16.C.	17.C.	18.A.	19.A.	20.C.
21.A.	22.A.	23.D.	24.A.	25.C.	26.A.	27.B.	28.C.	29.B.	30.D.
31.C.	32.A.	33.D.	34.D.	35.B.	36.D.				

Asosiy formulalar

Tezlik: $\upsilon_1 = \frac{\Delta x}{t} = \frac{\Delta s}{t}$.

Oniy tezlik: $\vec{\upsilon} = \lim\limits_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$ yoki $\vec{\upsilon} = \frac{d\vec{r}}{dt}$.

O'rtacha tezlik: $\vec{\upsilon}_{o'r} = \frac{s_{um}}{t_{um}}$

yoki $\upsilon_{o'r} = \frac{\Delta s_1 + \Delta s_2 + ... + \Delta s_n}{\Delta t_1 + \Delta t_2 + ... + \Delta t_n}$.

Ko'chish:

$\Delta \vec{r} = \vec{r}(t + \Delta t) - \vec{r}(t)$ *yoki* $\Delta \vec{r} = \vec{r}(x, y, z) - \vec{r}(x_0, y_0, z_0)$.

Bosib o'tilgan yo'l: $s_x = x - x_0 = \upsilon \cdot t$.

Tezlanish: $a = \Delta \upsilon / t = \frac{\upsilon - \upsilon_0}{t}$.

Tezlik, tezlanish va yo'l orasidagi bog'lanish:

$\upsilon^2 - \upsilon_0^2 = 2aS$. Agar $\upsilon_0 = 0$ bo'lsa,

$\upsilon^2 = 2aS$ *yoki* $\upsilon = \sqrt{2as}$

Burchak tezlik: $\omega = \frac{\Delta \varphi}{\Delta t} = \frac{\upsilon}{R}$.

Markazga intilma tezlanish:

$$a_n = \omega^2 R = 4\pi^2 \nu^2 R = \frac{4\pi^2}{T^2} R = \omega \cdot \upsilon.$$

Erkin tushish tezlanishi:

$$a = g = \gamma \frac{M}{R^2}.$$

Nyutonning I qonuni (inersiya qonuni):

Inersial sanoq sistemalarida jismga boshqa jism ta'sir etmasa yoki ularning ta'siri o'zaro kompensatsiyalansa, jism o'zining tinch holatini yoki to'g'ri chiziqli tekis harakatini saqlaydi.

Jismning tezligi. $\upsilon = 0$ *yoki* $\upsilon = \text{const}$

Nyutonning II qonuni:

$$\vec{F} = m\vec{a}$$

Nyutonning III qonuni:

$$\vec{F}_{21} = -\vec{F}_{12}$$

Butun olam tortishish qonuni:

$$F = F_{12} = F_{21} = \gamma \frac{m_1 \cdot m_2}{r^2}.$$

Jismning og'irligi;

$$\vec{P} = m\vec{g} + m\vec{a}$$

Guk qonuni:

$$F_{el} = -k \cdot \Delta x \qquad F_{el} = -k \cdot \Delta l$$

Jismning impulsi:

$$\vec{K} = m\upsilon.$$

O'zgarmas F kuchning ishi:

$$A = F \cdot r \cdot \cos\alpha \quad yoki \quad A = \left(\vec{F} \cdot \vec{r}\right).$$

Quvvat:

$$N = \frac{A}{t}.$$

Kinetik energiya:

$$E_k = \frac{m\upsilon^2}{2}.$$

Potensial energiya:

$$E_p = mgh.$$

Birinchi kosmik tezlik:

$$\upsilon_1 = \sqrt{\gamma \frac{M_{yer}}{R_{yer}}} = \sqrt{gR_{yer}} \approx 7{,}9 \text{ km / s}.$$

Ikkinchi kosmik tezlik:

$$\upsilon_{II} = \sqrt{\gamma \frac{M_{yer}}{R_{yer}}} \quad \text{yoki} \quad \upsilon_{II} = \sqrt{2}\upsilon_1 = \sqrt{2gR_{yer}} \approx 11{,}2 \text{ km/s}.$$

Uchinchi kosmik tezlik:

$$\upsilon_{III} = \sqrt{2} \cdot \upsilon_{orb} \approx 42{,}1 \text{ km/s}, \quad \text{bu yerda } \upsilon_{orb} = 29{,}8 \text{ km/s}.$$

Paskal qonuni:

$$P_x = P_y = P_z = P \quad \text{va} \quad \vec{P} = \text{const}.$$

Arximed kuchi:

$$F_A = \rho g V.$$

Bernulli tenglamasi:

$$p_1 + \rho g h_1 + \frac{\rho \upsilon_1^2}{2} = p_2 + \rho g h_2 + \frac{\rho \upsilon_2^2}{2} = \text{const}.$$

Torrichelli formulasi:

$$\upsilon = \sqrt{2gh}\,.$$

Kuch momenti:

$$M = F \cdot d.$$

Jismning aylanish o'qiga nisbatan inersiya momenti:

$$I = \sum_{i=1}^{n} \Delta m_i r_i^2\,.$$

Aylanma harakat dinamikasining asosiy tenglamasi:

$$M = I\varepsilon.$$

Molekular-kinetik nazariyaning asosiy tenglamasi:

$$P = \frac{1}{3} nm\bar{\upsilon}^2 = \frac{2}{3} n \cdot \frac{m\bar{\upsilon}^2}{2} = \frac{2}{3} n\bar{E}_k \quad \text{yoki} \quad P = \frac{1}{3} \rho\bar{\upsilon}^2.$$

Ideal gaz holat tenglamasi — Mendeleyev — Klapeyron tenglamasi:

$$PV = \frac{M}{\mu} RT.$$

Izotermik jarayon (T = const):

PV = const — Boyl-Mariott qonuni.

Izoxorik jarayon (V = const):

$p = C \cdot T = p_0 \alpha T$ — Sharl qonuni.

Izobarik jarayon (p = const):

$V = CT = V_0 \beta T$ — Gey-Lyussak qonuni.

Dalton qonuni:

$$p = p_1 + p_2 + p_3 + \ldots + p_n,$$

bu yerda p_i — parsial bosimlar.

Havoning nisbiy namligi:

$$\alpha = \frac{\rho}{\rho_0} \cdot 100\% \quad \text{yoki} \quad \varphi = \frac{P}{P_0} \cdot 100\%.$$

Termodinamikaning I qonuni:

$$Q = \Delta U + A \quad (\text{yoki} \quad \Delta U = Q + A').$$

Issiqlik miqdori:

$$Q = cm(t_2 - t_1) = cm\Delta t.$$

Issiqlik dvigatelining F.I.K:

$$\eta = \frac{A}{Q} \cdot 100\% \quad \text{va} \quad \eta = \frac{T_1 - T_2}{T_1} \cdot 100\%$$

Sirt taranglik kuchi koeffitsiyenti:

$$\sigma = \frac{F}{l}.$$

Zaryad saqlanish qonuni:

$q_1 + q_2 + q_3 + ... + q_n = \text{const}$ yoki

$q_1 + q_2 + q_3 + ... + q_n = q_1' + q_2' + q_3' + ... + q_n' = \text{const}.$

Kulon qonuni:

$$F_{12} = F_{21} = F = k\frac{|q_1| \cdot |q_2|}{\varepsilon r^2}; \quad k = \frac{1}{4\pi\varepsilon_0}.$$

Elektr sig'imi:

$$C = \frac{q}{U}.$$

Yassi kondensator sig'imi:

$$C = \frac{\varepsilon_0 \varepsilon S}{d}.$$

Sharning sig'imi: $C = 4\pi\varepsilon_0 R$.

Kondensatorlarni parallel ulash:

$$C_{um} = C_1 + C_2 + C_3 + ... + C_n,$$

$$U = U_1 = U_2 = U_3 = ... = U_n.$$

Kondensatorlarni ketma-ket ulash:

$$\frac{1}{C_{um}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}.$$

$$U_{um} = U_1 + U_2 + U_3 + ... + U_n.$$

Zanjirning bir qismi uchun Om qonuni:

$$I = \frac{U}{R}.$$

O'tkazgichlarni ketma-ket ulash:

$$U = U_1 + U_2 + U_3 = IR_1 + IR_2 + IR_3 = IR_{um}$$

$$R_{um} = R_1 + R_2 + R_3 \quad \text{yoki} \quad R = \sum_{i=1}^{n} R_i$$

O'tkazgichlarni parallel ulash:

$$\frac{1}{R_{um}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \frac{1}{R_{um}} = \sum_{i=1}^{n} \frac{1}{R_i}.$$

Butun zanjir uchun Om qonuni:

$$I = \frac{\varepsilon}{R+r}.$$

Klemmadagi kuchlanish:

$$U_{kl} = \varepsilon - Jr = JR.$$

Kirxgof qoidalari:

$$I_{kel} + I_{ket} = 0.$$

$$U_1 + U_2 + U_3 + \ldots + U_n = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \ldots + \varepsilon_n$$

Elektr tokining ishi:

$$A = IUt \quad \text{yoki} \quad A = I^2Rt \quad \text{yoki} \quad A = \frac{U^2}{R}t.$$

Joul-Lens qonuni:

$$Q = A = I^2Rt = IUt = \frac{U^2}{R}t.$$

Faradeyning I qonuni:

$$m = k \cdot q = k \cdot I \cdot t.$$

Faradeyning II qonuni:

$$k = \frac{1}{F} \cdot X = \frac{1}{F} \cdot \frac{A}{Z};$$

Faradeyning umumlashgan formulasi:

$$m = \frac{1}{F} \cdot \frac{A}{F} \cdot I \cdot t.$$

To'yinish tokining kattaligi – Richardson – Deshman formulasi:

$$I_T = BST_e^2 e^{-\frac{A}{kT}}.$$

Bio–Savara–Laplas qonuni:

$$\Delta B = \frac{\mu\mu_o}{4\pi} \cdot \frac{I \cdot \Delta l \cdot \sin\alpha}{r^2}.$$

Amper qonuni:

$$F_A = IBl\sin\alpha \quad \text{yoki} \quad \vec{F}_A = I\left[\vec{l} \cdot \vec{B}\right]...$$

Lorens kuchi:

$$F_l = q_o\upsilon\sin\alpha \quad \text{yoki} \quad F_l = q_o\left[\vec{\upsilon} \cdot \vec{B}\right].$$

Yorug'likning sinish qonuni:

$$\frac{\sin\alpha}{\sin\beta} = \frac{n_2}{n_1} = n.$$

Linzaning fokus masofasi:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right).$$

Linzaning optik kuchi:

$$D = \frac{1}{f}$$

Yupqa linza formulasi:

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f} = D.$$

Jismning tinchlikdagi energiyasi:

$$E_o = m_o c^2.$$

Fotoeffekt uchun energiyaning saqlanish qonuni — Eynshteyn formulasi:

$$h\nu = A + \frac{m\upsilon^2}{2}.$$

Atomning Bor modeli (planetar model):

$$h\nu_{min} = E_m - E_n.$$

Yadro reaksiyalari:

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H(p).$$

Yadro reaksiyalari vaqtida energiya ajralishi:

$$\Delta E = \Delta m \cdot c^2.$$

Yadro reaksiyalari uchun saqlanish qonunlari:

$$^{A1}_{Z1}Э + ^{A2}_{Z2}Э \rightarrow ^{A3}_{Z3}Э + ^{A4}_{Z4}Э, \qquad Z_1 + Z_2 = Z_3 + Z_4,$$

$$A_1 + A_2 = A_3 + A_4.$$

Termoyadro reaksiyasi:

$$^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + 17,7 MeV.$$

MUNDARIJA

I bob. MEXANIKA

II bob. MOLEKULAR FIZIKA

III bob. ELEKTR

Tursunmetov K.A., Po'latov M.
T 97 **Fizika:** Umumta'lim maktablari, akademik litsey, kasb-hunar kollejlari o'quvchilari hamda oliy o'quv yurtlariga kiruvchilar uchun. / K.A.Tursunmetov, M. Po'latov. – Toshkent.: «O'zbekiston» NMIU, 2016. – 176 b.

ISBN 978-9943-28-701-3

UO'K 53(075)
KBK 22.3ya7

KOMILJON TURSUNMETOV,
MIRALI PO'LATOV

FIZIKA

Umumta'lim maktablari, akademik litsey, kasb-hunar kollejlari o'quvchilari hamda oliy o'quv yurtlariga kiruvchilar uchun

Muharrir *N. G'oipov*
Badiiy muharrir *U. Sulaymonov*
Texn. muharrir *B. Karimov*
Musahhih *D. Mahmudova*
Kichik muharrirlar: *D. Xolmatova, G. Yeraliyeva*
Kompyuterda tayyorlovchi *K. Hamidullayeva*

Nashriyot litsenziyasi AI № 158, 14.08.2009.
Bosishga 2016-yil 14-dekabrda ruxsat etildi.
Bichimi $70x90^1/_{32}$. Ofset qog'oziga ofset usulida bosildi.
«Times TAD» garniturasi. Kegli 9,0. Shartli bosma tabog'i 6,41. Nashr tabog'i 8,56. Adadi 5000 dona.
Buyurtma № 16-838

O'zbekiston Matbuot va axborot agentligining «O'zbekiston» nashriyot-matbaa ijodiy uyi. Toshkent – 100011, Navoiy ko'chasi, 30-uy.

Oliy o‘quv yurtlariga kiruvchilar uchun

MA'LUMOTNOMA

«O‘ZBEKISTON»

ISBN 978-9943-28-701-3