3 ZINEMATIKA

$$\Delta\vec{r} = \vec{r}(t+\Delta t) - \vec{r}(t)$$

DESPLAZAMENDUA

$$\vec{v}_{bb} = \frac{\Delta\vec{r}}{\Delta t} \qquad \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta\vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$$

ABIADURA

$$\vec{a}_{bb} = \frac{\Delta\vec{v}}{\Delta t} \qquad \vec{a} = \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

AZELERAZIOA

4- ABIADURAREN ETA AZELERAZIOAREN OSAGAI INTRINTSEKOAK

$$a_T = \frac{|dv|}{dt}$$

AZELERAZIO TANGENTZIALA

$$a_N = \frac{v^2}{R}$$

AZELERAZIO NORMALA

$$a^2 = a_N^2 + a_T^2$$

AZELERAZIOA

· HIGIDURA ZUZENA

- H.Z.U.

$$x = x_0 + v \cdot t \qquad \left[\begin{matrix} v = kte \\ a = 0 \end{matrix}\right]$$

- H.Z.U.A

$$v = v_0 + a \cdot t$$

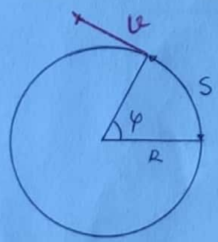
$$x = x_0 + v_0 \cdot t + \frac{1}{2} a \cdot t^2$$

$$v^2 - v_0^2 = 2a \cdot (x - x_0)$$

$$[a = kte]$$

$$v = \sqrt{v_0 + 2gh}$$

· HIGIDURA ZIRKULARRA



$$S = \varphi \cdot R$$

$$\omega = \frac{d\varphi}{dt} \quad (rad/s)$$

ABIADURA ANGELUARRA

$$\alpha = \frac{d\omega}{dt} \quad (rad/s^2)$$

AZELERAZIO ANGELUARRA

$$[a_T = \alpha \cdot R]$$

$$v = \omega \cdot R$$

$$a_N = \frac{v^2}{R} = \omega^2 \cdot R$$

$$a_T = \frac{(\omega \cdot R)}{t}$$

$$[\vec{a} = \vec{a}_N + \vec{a}_T]$$

SHOT ON MI 9T

H.Zir.k.U

$$\boxed{\varphi = \varphi_0 + w \cdot t}$$

[$w = kte$ $\alpha = 0$]

$$\boxed{S = S_0 + v \cdot t}$$

H.Zir.k.U.A.

$$\boxed{w = w_0 + \alpha \cdot t}$$

$$\boxed{\varphi = \varphi_0 + w_0 \cdot t + \frac{1}{2} \alpha \cdot t^2}$$

$$\boxed{w^2 - w_0^2 = 2\alpha \cdot (\varphi - \varphi_0)}$$

[$\alpha = kte$]

$$\boxed{S = S_0 + v_0 \cdot t + \frac{1}{2} a t^2}$$

6- HIGIDURA ERLATIBODUN ERREFERENTZIA SISTEMAK

$$\left[\vec{r} = \vec{R} + \vec{r'} \qquad \vec{v} = \vec{V} + \vec{v'} \qquad \vec{a} = \vec{A} + \vec{a'} \right]$$

4 MEKANIKA

NEWTONEN LEGEAK

1.- BALDIN $\vec{F}_{tot} = 0$ ORDUAN $\vec{v} = kte$

2.- $\vec{F}_{tot} = m \cdot \vec{a}$

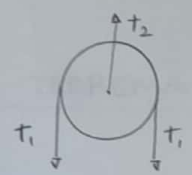
3.- $\vec{F}_{12} = -\vec{F}_{21}$

3.- INDARREN ADIBIDEAK

① PISUA $\boxed{\vec{P} = m \cdot \vec{g}}$

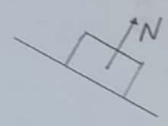
② MALGUKIAREN INDARRAK $\boxed{F = Kx}$

③ TENTSIOA SOKETAN



$\boxed{T_2 = 2T_1}$

④ INDAR NORMALA



$\boxed{N \perp}$

⑤ MARRUSKADURA INDARRA $\boxed{F_R \leq \mu \cdot N}$ [IRRIST. (=) / EZ IRR. (<)]

4.- ERREFERENTZIA SISTEMA AZELERATUAK

$\boxed{\vec{F}_{tot} = m \cdot \vec{a}}$ SISTEMA INERTZIALETAN

$\boxed{\vec{F}_{tot} - m\vec{A} = m\vec{a}}$ ($\vec{A}$ inertzianekiko

SISTEMA EZ-INERTZIALA

5 PARTIKULAREN DINAMIKA OROKORRA

1.- HELBURU NAGUSIA

$$\boxed{\vec{v}-\vec{v}_0=\int_{t_0}^{t}\frac{F}{m}\,dt}\qquad\boxed{\vec{r}-\vec{r}_0=\int_{t_0}^{t}v\cdot dt}$$

2.- PARTIKULA BATEN TEOREMAK: MOMENTU LINEALA

$\vec{p}=m\cdot\vec{v}\ (kg\cdot m/s)$

MOMENTU LINEALA

$\vec{F}=\dfrac{d\vec{p}}{dt}$

MOMENTU LINEALAREN TEOREMA

$I=\Delta\vec{p}=\vec{F}\cdot\Delta t$

INPULTSOA / BULKADA

$\vec{p}$ kontserbazioa / $\vec{p}=kte$

BALDIN : $\vec{F}_{tot}=0$

2.2- MOMENTU ANGELUARRAREN TEOREMA

$\vec{L}=\vec{r}\times\vec{p}$

MOMENTU ANGELUARRA

- PUNTU JAKIN BATEAN -

$[\,L=r\cdot p\cdot\sin\underset{0}{\theta}\rightarrow\vec{v}\parallel\vec{p}\,]$

$M_0=\dfrac{d\vec{L}_0}{dt}=\vec{r}\times\vec{F}_{tot}$

MOMENTU ANGELUARRAREN TMA

- TORTSIO MOMENTUA PUNTU JAKIN BATEAN -

$\vec{L}$ kontserbazioa / $\vec{L}_0=kte$

BALDIN : $\vec{M}_0=0$

2.3.- PARTIKULA BATEN ENERGIAREN TEOREMA

$dW=\vec{F}\cdot d\vec{r}$

INFINITESIMALA

$W=\int_{r_1}^{r_2}\vec{F}\cdot d\vec{r}$

FINITUA

$$\boxed{W=\Delta E_z}\qquad\boxed{W=P\cdot t}$$

$P=\dfrac{dW}{dt}=\vec{F}\cdot\vec{v}\quad(J/s=kg\ m^2/s^3=Watt)$

POTENTZIA

$$\boxed{P=\frac{dE_z}{dt}}$$

3.- POSIZIOAREN MENDEKO INDARRAK

· F KONTSERBAKORRA

$\boxed{\Delta E_p = -W}$ $\quad \boxed{\Delta E_p = -\int \vec{F} \cdot d\vec{r} = E_p(r_2) - E_p(r_1)}$ $\quad [dE_p = \vec{F}_{(r)} \cdot d\vec{r}]$

- MALGUKIEN INDAR ELASTIKOA

$$\boxed{E_p(x) = \frac{kx^2}{2}} \qquad \boxed{\Delta E_p = -\int_{x_0}^{x} kx \cdot dx}$$

- GRABITATEA

$$\boxed{E_p(y) = mg \cdot y} \qquad \boxed{\Delta E_p = -\int_{y_0}^{y} m \cdot g \cdot dy}$$

- KONTSERBAZIOA -

$$\begin{bmatrix} W_{TOT} = -\Delta E_p \\ W_{TOT} = \Delta E_z \end{bmatrix} \Rightarrow \left[\Delta E_z = -\Delta E_p \right] \quad \begin{cases} \Delta E_z + \Delta E_p = 0 \\ E_z + E_p = Kte = E_{MEK} \end{cases}$$

- BALDIN

$$\boxed{F_{TOT} = F_k + F_{EK}}$$

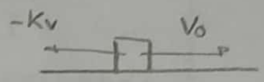
$$\Delta E_z = W_{tot} = \underbrace{W_k}_{-\Delta E_p} + W_{EK}$$

$$\boxed{\Delta E_z + \Delta E_p = W_{EK} \rightarrow W_{EK} = E_{MEK}}$$

6- ABIADURAREN MENPEKO INDARRA

- $\vec{F}(\vec{v}) = m \cdot \vec{a}$

DIMENTSIO BAKARRA $\left\{ -\underline{k} \cdot v^n = m \cdot \dfrac{dv}{dt} \right.$



INDAR kte.

$$\boxed{v = v_0 \cdot e^{-(K/m)\cdot t}}$$

$$\boxed{x = \left(1 - e^{-(K/m)t}\right) \cdot \frac{m v_0}{K}}$$

$$\left[\begin{array}{l} t = 0 \longrightarrow x = 0 \\ t = \infty \longrightarrow x = \dfrac{m v_0}{k} \end{array}\right]$$

$$\boxed{x = -\frac{m}{k}(v - v_0)}$$

6 HIGIDURA OSZILAKORRA

1. SARRERA

$\boxed{f = \frac{1}{T}}$ (Hz) T (s)

$$\boxed{\omega = 2\pi f = \frac{2\pi}{T}}$$

MAIZTASUN ANGELUARRA

$$\boxed{F = -kx}$$

INDAR BERRESKURATZAILEA

2. ADIERAZPEN MATEMATIKOA

$F = m \cdot a \longrightarrow \boxed{-kx = m \cdot a = F \quad [a = \ddot{x}] \quad \ddot{x} = -\frac{k}{m}x}$

[H.H.S-ren EKUAZIOA]: $\boxed{\ddot{x} + \omega_0^2 x = 0}$

- non $\boxed{\omega_0 = \sqrt{\frac{k}{m}}}$:

$$\boxed{x = A \cdot \sin(\omega_0 t + \delta)}$$

$$\boxed{\dot{x} = v = A \cdot \omega_0 \cos(\omega_0 t + \delta)}$$

$$\boxed{\ddot{x} = a = \underbrace{-A \cdot \omega_0^2}_{max} \cdot \sin(\omega_0 t + \delta)}$$

HASIERAKO FASEA

$$\boxed{\delta = \arctan\left(\frac{x_0 \cdot \omega_0}{v_0}\right)}$$

ANPLITUDEA

$$\boxed{A = \frac{\sqrt{v_0^2 + x_0^2 \omega_0^2}}{\omega_0}}$$

PERIODOA

$$\boxed{T = \frac{2\pi}{\omega_0} = 2\pi\sqrt{\frac{m}{k}}}$$

- Gerbendireko H.H.S-ak

[1] PENDULUA

$$\left[\begin{array}{l} \ddot{\theta} + w_0^2\,\theta = 0 \\ w_0 = \sqrt{g/l} \end{array}\right]$$

[3] JIRACHINAS

$$\left[\begin{array}{l} \ddot{x} + w_0^2 \cdot x = 0 \\ w_0 = \sqrt{\frac{2T}{l\,m}} \end{array}\right]$$

- Energia

$$\boxed{E_{mek} = E_p^{max} = E_z^{max} = \frac{1}{2} m A^2 \cdot w_0^2 = \frac{1}{2} k A^2}$$

$$\left[E_p = \frac{1}{2} k x^2 \qquad E_z = \frac{1}{2} m \dot{x}^2 \right]$$

SHOT ON MI 9T
AI TRIPLE CAMERA

7 PARTIKULA SISTEMEN DINAMIKA

2. PARTIKULA SISTEMEN TMA-K

· MOMENTU LINEALA :

$$\boxed{\vec{F}^{KAN}_{TOT} = \frac{d\vec{p}_{TOT}}{dt}}$$

$$\underbrace{\cancel{\vec{F}_{1\to2} + \vec{F}_{2\to1}}}_{\text{BARNEKOA}} + \underbrace{\vec{F}^{KAN}_{1} + \vec{F}^{KAN}_{2}}_{=}$$

=

BALDIN
$\vec{F}^{KAN} = 0$
$\vec{p} = kte$

· MOMENTU ANGELUARRA :

$$\boxed{\vec{L} = \vec{r} \times \vec{p} \qquad M = \vec{r} \times \vec{F}} \qquad \boxed{M = \frac{dL}{dt}}$$

$[\vec{M}^{BAR} = 0]$

BALDIN
$\vec{M}^{KAN} = 0$
$\vec{L} = kte$

$$\left[\vec{M}_1 + \vec{M}_2 = \frac{d(\vec{L}_1 + \vec{L}_2)}{dt} \right.$$
$$\Downarrow$$
$$M_1^{KAN} + M_1^{BAR} + M_2^{KAN} + M_2^{BAR}$$
$$\Downarrow$$
$$\left. \vec{M}^{KAN} \right]$$

· ENERGIA :

$$\boxed{\Delta E_2 = W_{BAR} + W_{KAN}} \qquad [\Delta E_2 = W]$$

3.- TALKAK

$$\boxed{\vec{P}_{TOT} = kte}$$

$$\left[m_1 \cdot v_1 + m_2 \cdot v_2 = m_1 v_1' + m_2 v_2' \right.$$

$$\left. \underbrace{W^{BAR}}_{} = \underbrace{\frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2}_{E_2'} - \underbrace{\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2}_{E_2} \right]$$

$\to$ $\boxed{0}$ = TALKA ELASTIKOA

$\boxed{<0}$ = TALKA PARTZIALKI INELASTIKOA

$\boxed{v_1' = v_2'}$ = TALKA PLASTIKOA

$$\boxed{v_2' - v_1' = -e(v_2 - v_1)}$$

[e = ITZULTZE KOEF.]

$e = 1$ TALKA ELASTIKOA
$0 < e < 1$ TALKA INELASTIKOA
$0 = e$ TALKA PLASTIKOA

4. MASA ZENTROA

$$\boxed{R_{MZ} = \frac{\sum_{i=1}^{n} m_i \vec{r_i}}{M}}$$

$$\boxed{V_{MZ} = \frac{\sum_{i=1}^{n} m_i \vec{v_i}}{M}}$$

$$\boxed{\vec{F}^{KAN} = \frac{d\vec{P}}{dt} = M\frac{d\vec{V}}{dt} = M\vec{A}_{MZ}}$$

5.- DESKONPOSAKETA

$$\vec{P} = \sum_{i=1}^{n} m_i \cdot \vec{v_i} = M \cdot \vec{V}_{MZ}$$

$$\vec{L} = \sum_{i=1}^{n} \vec{r_i} \times m_i \cdot \vec{v_i} = \vec{R}_{MZ} \times M\vec{V}_{MZ} + \vec{L'}$$

$$E_Z = \sum_{i=1}^{n} \frac{1}{2} m_i \vec{v_i}^2 = \frac{1}{2} M \cdot \vec{V}_{MZ}^2 + E_Z'$$

$$M_{MZ}^{KAN} = \frac{d\vec{L'}}{dt}$$

8 SOLIDO ZURRUNAREN DINAMIKA
(ERROTAZIOA)

2.- SOLIDO ZURRUNAREN ESTATIKA

$$\boxed{\vec{F}_{tot} = \sum_{i=1}^{n} \vec{F}_i = 0}$$

$$\left[\vec{F}^{KAN} = M \cdot \vec{A}_{MZ} = \frac{d\vec{p}}{dt}\right]$$

$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum F_z = 0 \end{cases}$$

$$\boxed{\vec{M}^{KAN}_{tot} = \sum_{i=1}^{n} \vec{M}_i = 0}$$

$$\left[\vec{M}^{KAN} = \frac{dL}{dt}\right]$$

INDAR BATEN MOMENTUA PTO JAKIN BATEAN → $\vec{M} = \vec{r} \times \vec{F}$

$$\boxed{M = F \cdot d}$$

3.- SOLIDO ZURRUNAREN ERROTAZIOREN DINAMIKA ARDATZ FINKO BATEN MODUAN

$$\left[dL_0 = \vec{r} \times d\vec{p}\right] \rightarrow \boxed{L_{0z} = w\int r^2 dm = w \cdot I}$$

INERTZIA MOMENTUA

$$\boxed{I = \int r^2 dm \quad (kg \cdot m^2)}$$

SOLIDOAREN ERROTAZIOA DINAMIKOA EKUAZIOA

$$\boxed{\vec{M} = I \cdot \vec{\alpha}}$$

[INERTZI TAULA]

SIMETRIA BADU EDO Z ARDATZ. INGURUAN

$$\boxed{L_x = L_y = 0 \qquad \vec{L} = L_z}$$

4.- INERTZIA ARDATZ NAGUSIAK - STEINER TMA

$$\left[I_p > I_{MZ}\right] \qquad \boxed{I_p = I_{MZ} + M \cdot d^2}$$

ARDATZ PARALELOEN TMA.

5.- ERROTAZIOA, ENERGIA ZUZENAREKIKO

$$\boxed{E_z = \frac{1}{2} I_p w^2}$$

ERROTATZEN DAGOENEAN MZ

$$\boxed{E_z = \frac{1}{2} I_p w^2}$$

ERROTAZIO HUTSA

$$\boxed{E_z = \frac{1}{2} I_{MZ} \cdot w^2 + \frac{1}{2} M V_{MZ}^2}$$

POTENTZIA:

$$\boxed{P = F \cdot v = M w}$$

- ENERGIA POTENTZIALA

$$\boxed{E_p = g \cdot z_{mz} \cdot M} \qquad \boxed{z_{mz} = \frac{1}{M}\int_M z \, dm}$$

10 FLUIDOAK

- DENTSITATEA

$$\boxed{\rho = \frac{m}{V} \quad (kg/m^3)}$$ [URA: $1\ g/cm^3$]

- PRESIOA

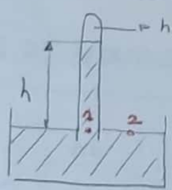
$d\vec{F} = P \cdot d\vec{s}$ $$\boxed{P = \frac{dF}{ds} \quad (N/m^2 \cdot Pa)}$$ $\left[P = \frac{F}{S}\right]$

3- FLUIDOEN ESTATIKA

$[P_{atm} = 1{,}013 \cdot 10^5\ Pa]$ $$\boxed{P = P_{atm} + \rho g z}$$

4- APLIKAZIOAK

4.1.- MERKURIOZKO BAROMETROA

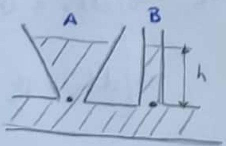


$[P_1 = P_2]$ $$\boxed{P_{atm} = \rho g h}$$

GAINEAN DUENA DA PRESIOA

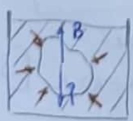
$$\left[\begin{array}{l} P_1 = \rho g h \\ P_2 = P_{atm} \end{array}\right]$$

4.2.- ONTZI KOMUNIKATUAK



$\boxed{P_A = P_B} \Longleftrightarrow [h_A = h_B]$

4.3.- ARKIMIDESEN PRINTZIPIOA



- LIKIDOA: $\boxed{P = B}$
- SOLIDOA: $[P_s = mg = \rho_s \cdot V \cdot g] \Rightarrow$

$$\boxed{\begin{array}{ll} B < P_s & \text{HONDORATU} \\ B = P_s & \text{OREKAN} \\ B > P_s & \text{GAINAZALERA} \end{array}}$$

- FLOTAZIOA

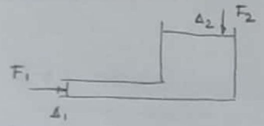
- V_m = BOLUMEN MURGILDUA
- V = BOLUMEN OSOA

} SOLIDO

- B' = BULTZADA
- ORDEZKATUTAKO LIKIDOAREN PISUA $= V_m \cdot \rho_l \cdot g = B'$
- P_s = SOLIDOAREN PISUA $= V \cdot \rho_s \cdot g$

$$\boxed{V \cdot \rho_s = V_m \cdot \rho_l} \leftarrow [B' = P_s]$$

4.4. PASCALEN PRINTZIPIOA



$$\boxed{\frac{F_1}{A_1} = \frac{F_2}{A_2}}$$

5.- FLUIDOEN DINAMIKA

→ KORRONTE - LERROA

→ KORRONTE - HODIA

MARRUSKADURA EZ → [HORMAK, BISKOSITATEA]

5.1. FLUXUA (EMARIA)

$$\phi = \frac{dV}{dt} = \left(\frac{m^3}{s}\right) = \frac{S \cdot v \cdot \cancel{dt}}{\cancel{dt}} = \boxed{S \cdot v = \phi}$$

5.2. JARRAITASUN EKUAZIOA

$$dV_1 = S_1 dl_1 = S_1 v_1 \cdot dt \rightarrow \left[\begin{array}{l} dl_1 = v_1 dt \\ dl_2 = v_2 \cdot dt \end{array}\right]$$

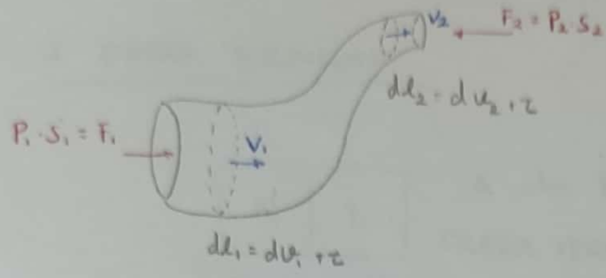
- FLUIDOA KONPRIMAEZINA BADA : $\boxed{dV_1 = dV_2}$

$S_1 \cdot dl_1 = S_2 \cdot dl_2 \rightarrow S_1 v_1 \cancel{dt} = S_2 \cdot v_2 \cancel{dt}$ $\quad \boxed{S_1 \cdot v_1 = S_2 v_2}$

FLUXUAREN KONTSERBAZIOA $[Sv = kte]$

- KONPRIMAGARRIA BADA : $\boxed{dw_1 = dw_2}$

5.3.- BERNOULLI-REN EKUAZIOA (ENERGIAREN KONTSERBAZIOA)



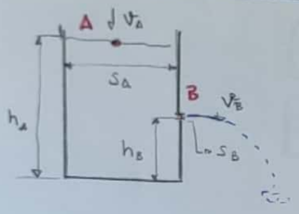
$$\Delta E_k = W_{tot} = \underbrace{W_p} + \underbrace{W_g} = \underbrace{F_1 dl_1 - F_2 dl_2} + \underbrace{(-\Delta E_p)}$$

$$\left[\Delta E_k = \frac{1}{2} dm_2 v_2^2 - \frac{1}{2} dm_1 \cdot v_1^2 \right]$$

$$\boxed{P + \frac{1}{2}\rho v^2 + \rho g h = kte}$$ BERNOULLIREN EKUAZIOA

6.- APLIKAZIOAK

6.1.- TORRICHELLIREN FORMULA (ONTZIA HUSTU)

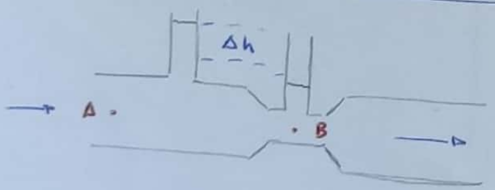


$$\left[\begin{array}{ll} v_A \cdot S_A = S_B \cdot v_B & P_A = P_B = P_{atm} \\ P + \frac{1}{2}\rho v^2 + \rho g h = kte & \Rightarrow v_B^2 = 2g(h_A - h_B) \end{array} \right]$$

$$\boxed{v_B = \sqrt{2gh}}$$

ZULOTXO TXIKIA: $S_B <<< S_A \Rightarrow v_B >>> v_A$

6.2.- VENTURI EFEKTUA

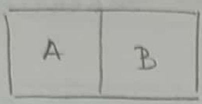


$$\left[\begin{array}{l} S_A \cdot v_A = S_B \cdot v_B \\ P_A - P_B = \rho g \Delta h \\ P + \frac{1}{2}\rho v^2 + \rho g h = kte \end{array} \right] \rightarrow \rho g \Delta h = \frac{1}{2}\rho\left(\frac{S_A^2}{S_B^2} - 1\right) v_A^2$$

$$\boxed{v_A = \sqrt{\frac{2g\,\Delta h}{\left(\frac{S_A}{S_B}\right)^2 - 1}}}$$

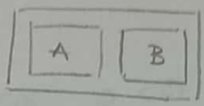
[III] TERMO: 1 PRTZP.

2.- OREKA TERMIKOA



HORMA DIATERMIKOA

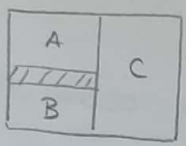
A eta B OREKA TERMIKOA



HORMA ADIABATIKOA

A eta B **EZ** OREKA TERMIKOAN

3.- "ZERO" PRINTZIPIOA

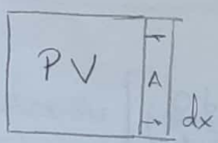


[A eta C OREKAN
B eta C OREKAN } ⟹ A eta B OREKAN]

[TENPERATURA ESKALAK ⟶ KELVIN]

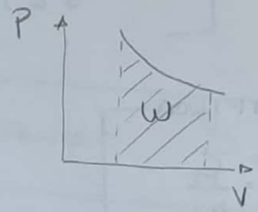
[GAS IDEALAK $PV = nRT$]

4.- LAN HIDROSTATIKOA



$$dW = F \cdot dx = P \cdot A\, dx = P \cdot dV$$

$$\boxed{W = \int_{V_h}^{V_a} P\, dV}$$



5.- BARNE ENERGIA

$$\boxed{E = E_z + E_p}$$

MOLEKULA

$$U = \sum_{i=1}^{n} E_{z_i}$$

MOLEKULA GUZTIEN BATURA

MOLEKULEN HIGIDURA ASKATASUN GRADU BAKOITZEKO

$U = \frac{3}{2} nRT$ (MONOATOMIKO) [3 askatasun gradu]

$U = \frac{5}{2} nRT$ (DIATOMIKO) [5 askatasun gradu]

6.- TERMODINAMIKAREN 1. PRINTZIPIOA

a) $\left[\Delta U = -W\right]$ BERO TRASFERENDIARIK EZ $\Rightarrow$ HORMA ADIABATIKOAK

b) $\left[\Delta U = Q\right]$

$Q > 0$ BEROA XURGATU

$Q < 0$ BEROA EMAN

LANA DAGOENEAN $\leftarrow$ ⓐ + ⓑ $\rightarrow$ BERO TRASFERENTZIA DAGOENEAN

$$\boxed{\Delta U = Q - W}$$

7.- BERO AHALMENA

$$\boxed{C = \frac{Q}{T_a - T_h} = \frac{Q}{\Delta T}} \longrightarrow \boxed{\frac{\delta Q}{\delta T} = C}$$

$(J/K)\ (cal/K)$

Ⓐ $[V\ kte]$ $\left[C_V = \left(\frac{\delta Q}{\delta T}\right)\right]$ Ⓑ $[P\ kte]$ $\left[C_P = \left(\frac{\delta Q}{\delta T}\right)\right]$

- BERO ESPEZIFIKOA

$$c = \frac{C}{m} \qquad c = \frac{C}{n_{mol}}$$

Ⓐ $\boxed{V\ kte}$

$C_V = \frac{3}{2} nR$ (MONOATOMIKOA)

$C_V = \frac{5}{2} nR$ (DIATOMIKOA)

Ⓑ $\boxed{P\ kte}$

$C_P = \frac{5}{2} nR$ (MONOATOMIKOA)

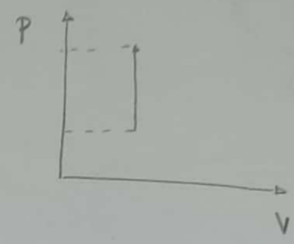
$C_P = \frac{7}{2} nR$ (DIATOMIKOA)

8. PROZESU KUASIESTATIKOAK GAS IDEALETAN

· PROZESU ISOKOROAK (V kte)

$$\boxed{Q = C_v \cdot \Delta T}$$
$$\boxed{\Delta U = C_v \cdot \Delta T}$$
$$\boxed{W = 0}$$

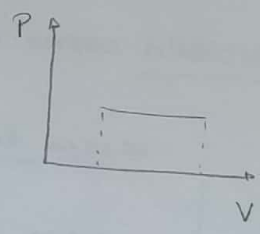
$$\Delta U = Q - W \qquad \boxed{\Delta U = Q}$$



· PROZESO ISOBAROAK (P kte)

$$\boxed{W = P \cdot \Delta V}$$
$$\boxed{Q = C_p \cdot \Delta T}$$
$$\boxed{\Delta U = C_v \, \Delta T}$$

$$\Delta U = Q - W$$
$$\boxed{C_v = C_p - nR}$$

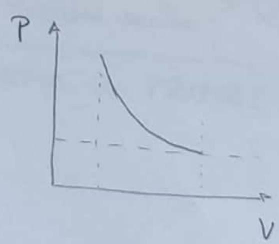


$\Delta V > 0$ ESPANTSIO $\quad \Delta V < 0$ KONPRESIO

· PROZESU ISOTERMIKOAK (T kte)

$$\boxed{\Delta U = 0}$$
$$\boxed{W = nRT \ln\left(\frac{V_a}{V_h}\right)}$$
$$\boxed{Q = nRT \ln\left(\frac{V_a}{V_h}\right)}$$

$\frac{V_a}{V_h} > 1$ ESPANTSIO $\quad \frac{V_a}{V_h} < 1$ KONPRESIO

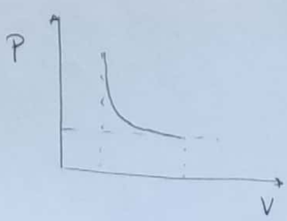


· PROZESU ADIABATIKOAK

$$\boxed{\delta W = \frac{nRT}{V} dV}$$
$$\boxed{Q = 0}$$
$$\boxed{W = -C_v \Delta T}$$
$$\boxed{\Delta U = C_v \Delta T}$$

$$\boxed{P V^{\gamma} = kte}$$ INDIZE ADIABATIKO

$$\gamma = \frac{C_p}{C_v} \quad \Big| \quad \gamma = 5/3 \ (\text{MONO}) \qquad \gamma = 7/5 \ (\text{DIAT.})$$



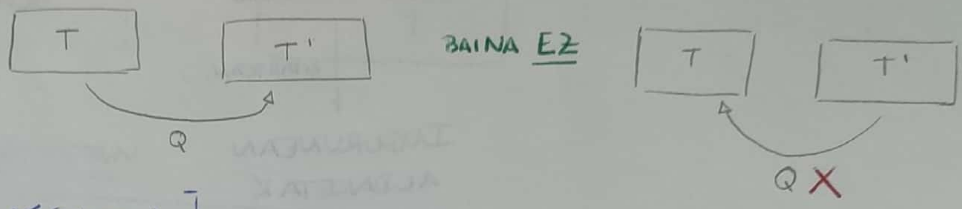
$\Delta U > 0 \quad \Delta T > 0$

Escaneado con CamScanner

12 TERMO. 2. PRINTZIPIOA

- 1. PRINTZIPIOA

$T > T'$



$$\left[\begin{array}{lll} W \longrightarrow Q & \checkmark\ (100\%) \\ Q \longrightarrow W & \times\ (100\%) \end{array}\right]$$

2: ENTROPIA: 2. PRINTZIPIOA

[SISTEMA MAKROSKOPIKOAK → ALDAGAI TERMODINAMIKOAK

ALDAGAI TERMODINAMIKOAK → SISTEMAREN EGOERA MIKROSKOPIKOEKIN]

[OREKA SISTEMA | - ALDAGAI TERMODINAMIKOAK EZ ALDATU
- EGOERA MIKROSKOPIKOA ETENGABE ALDATU]

PISU ESTATIKOA Ω : $\Omega = \Omega(V, T)$ [EGOERA FUNTZIO]

"EGOERA MAKROSKOPIKO BATEN ZENBAT EGOERA MIKROSKOPIKO"

ENTROPIA: $\boxed{S = \underbrace{k_B}_{\text{BOLTZMAN kte}} \cdot \ln \Omega}$

$\boxed{\Delta S_{\text{sistema isolatua}} > 0}$ TERMO: 2. PRNTZP.

$$\left[\begin{array}{ll} \Delta S > 0 & \rightarrow \text{prozesu posiblea} \\ \Delta S < 0 & \rightarrow \text{PROZESUA EZ POSIBLE} \end{array}\right]$$

3.- PROZESU IRULGARRIAK ETA IRULEZINAK

OREKA APURTU → SISTEMAK EBOLUZIONATU → OREKA BERRIA

↓ BITARTEAN...

INGURUNEAN ALDAKETAK

- ITZULEZINAK: Noranzko BAKARRA
- IRULGARRIAK: BI Noranzko

4.- ENTROPIA ALDAKETEN KALKULUA

$$\left[dS = \frac{\delta Q_{irz.}}{T} \right] \longrightarrow \boxed{\Delta S = \int_h^a \frac{\delta Q_{irzg}}{T}}$$

a) $\boxed{V = Kte}$ ISOKORO IRULGARRIAK

XURGATUTAKO BEROA

$$\left[\delta Q_{irzg.} = C_v \, dT \right] \longrightarrow \boxed{\Delta S = C_v \ln \frac{T_a}{T_h}}$$

b) $\boxed{P = Kte}$ ISOBARO IRULGARRIAK

XURGATUTAKO BEROA

$$\left[\delta Q_{irzg.} = C_p \, dT \right] \longrightarrow \boxed{\Delta S = C_p \ln \frac{T_a}{T_h}}$$

c) $\boxed{T = Kte}$ ISOTERMO IRULGARRIAK

$$\left[\delta Q_{irzg.} = nRT \frac{dV}{V} \right] \longrightarrow \boxed{\Delta S = nR \ln \frac{V_a}{V_h}}$$

d) ADIABATIKO IRULGARRIAK

$$\left[\delta Q_{irzulg.} = 0 \right] \quad \boxed{\Delta S = 0}$$

e) FOKU BAT

$$C \to \infty \begin{bmatrix} - Q \text{ aldatu} \\ - T = \text{kte} \end{bmatrix} \Rightarrow \boxed{\Delta S = \frac{Q_{foku}}{T}}$$

- PROZESU IRULEZINETAN

$$\boxed{\Delta S_{foku} < 0 + \Delta S_{gas} > 0 = \Delta S_{UNIBERTSOA} > 0}$$

5.- BESTE ADIERAZPENAK

- CLAUSIUS-EN ADIERAZPENA:

$$\boxed{T} \xrightarrow{Q} \boxed{T'} \qquad \boxed{T' < T} \qquad [\Delta S_{tot} = \Delta S_{uni} > 0]$$

- KELVIN PLANK-EN ADIERAZPENA

$$\left[\Delta S_{tot} = \Delta S_T = \frac{Q_{XUR}}{T} = \frac{-Q}{T} < 0\right] \quad \text{BATERAEZINA!}$$

6.- MOTORE TERMIKOAK

$$[\Delta U_{motor} = Q_{XUR} - Q'_{EMAN} - W_{TRANSFORM} = 0] \qquad \boxed{W = Q - Q'}$$

- ETEKINA

$$\boxed{\eta = \frac{W}{Q_{XUR}} \leq 1}$$

- CARNOT

$$\boxed{\eta_{max} = 1 - \frac{T'}{T}}$$