Тема 2

a / Galileo Galilei (1564-1642).

Галилеев принцип за относителност

The Principle of Inertia

No force is required to maintain motion with constant velocity in a straight line, and absolute motion does not cause any observable physical effects.

Discussion question D.

Нютонова механика. Инертна маса на телата

1.First law: The velocity of a body remains constant unless the body is acted upon by an external force.[3][4][5]

$$\sum \mathbf{F} = 0 \Rightarrow \frac{d\mathbf{v}}{dt} = 0.$$

2.Second law: The acceleration a of a body is parallel and directly proportional to the net force **F** and inversely proportional to the mass m, i.e., **F** = m**a**.

$$\mathbf{F} = \frac{\mathrm{d}\mathbf{p}}{\mathrm{d}t} = \frac{\mathrm{d}(m\mathbf{v})}{\mathrm{d}t},$$

$$\mathbf{F} = m\,\frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} = m\mathbf{a},$$

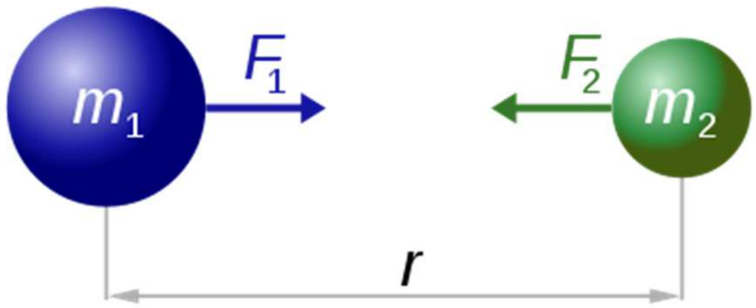
3.Third law: The mutual forces of action and reaction between two bodies are equal, opposite and collinear.

$$\sum \mathbf{F}_{a,b} = -\sum \mathbf{F}_{b,a}$$

Закон за гравитацията. Гравитационна маса.

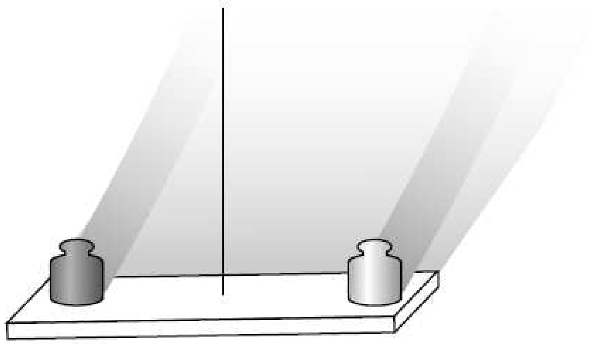
$$G = 6.67384(80) \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}} =$$

$$= 6.67384(80) \times 10^{-11}\ \mathrm{N\,(m/kg)^2}$$

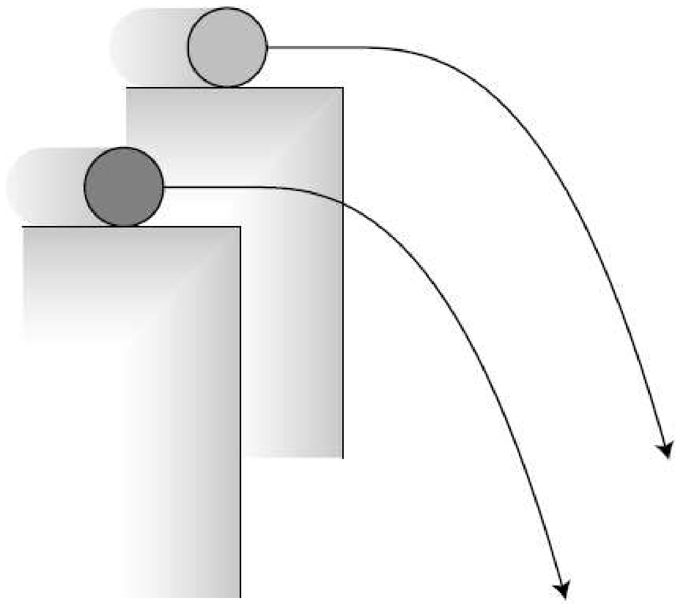


$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

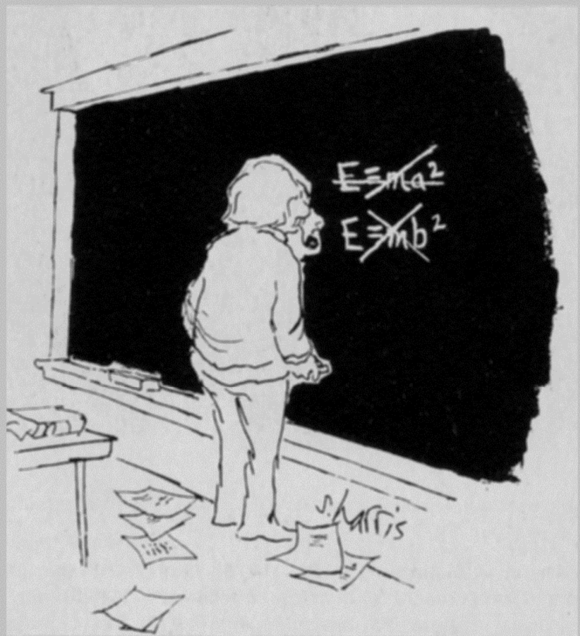
Равенство на инертната и гравитационната маса



c / A simplified drawing of an Eötvös-style experiment. If the two masses, made out of two different substances, have slightly different ratios of inertial to gravitational mass, then the apparatus will twist slightly as the earth spins.



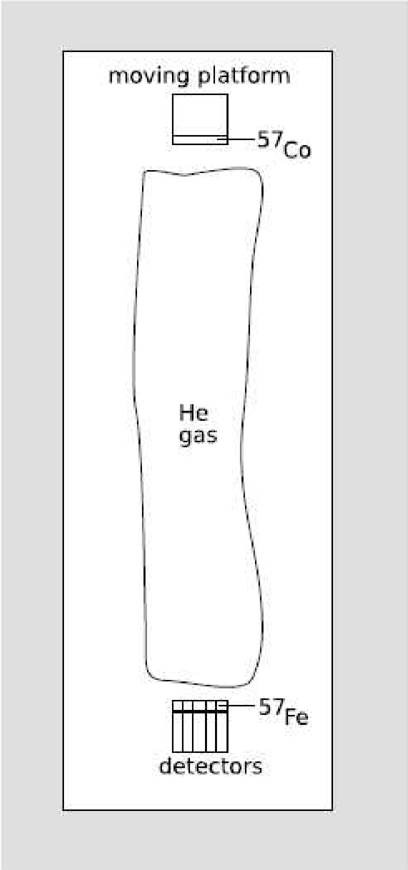
b / If the cylinders have slightly unequal ratios of inertial to gravitational mass, their trajectories will be a little different.

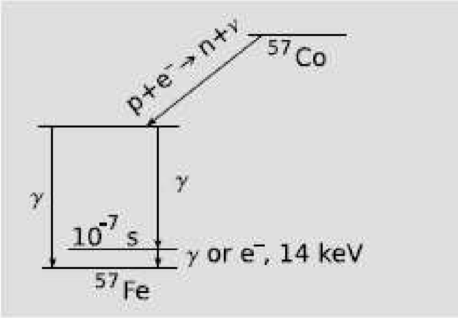


Фиг. 1.3. Алберт Айнщайн (Albert Einstein, 1879–1955). На карикатурата художникът Сидни Харис е нарисувал една фигура, в която веднага може да бъде разпознат зрелият Айнщайн. Всъщност той е бил млад човек, когато е извел $E = mc^2$. Снимката е направена приблизително по времето (1905), когато е публикувал *специалната теория на относителността*. Това е едно от многото му забележителни достижения в областта на теоретичната физика, като най-голямото от всички е *общата теория на относителността*, публикувана през 1915 г.

Експеримент на Pound& Rebka (Harward, 1960 г.)

r / Pound and Rebka at the top and bottom of the tower.





p / Emission of 14 keV gamma-rays by ^{57}Fe. The parent nucleus ^{57}Co absorbs an electron and undergoes a weak-force decay process that converts it into ^{57}Fe, in an excited state. With 85% probability, this state decays to a state just above the ground state, with an excitation energy of 14 keV and a half-life of 10^{-7} s. This state finally decays, either by gamma emission or emission of an internal conversion electron, to the ground state.

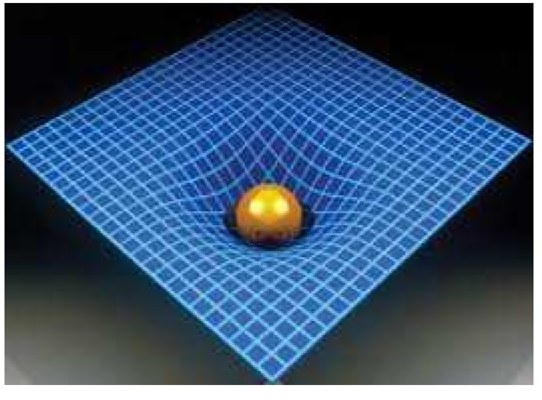
For $y = 22.6$ m, the equivalence principle predicts a fractional frequency shift due to gravity of 2.46×10^{-15}. Pound and Rebka measured the shift to be $(2.56 \pm 0.25) \times 10^{-15}$. The results were in statistical agreement with theory, and verified the predicted size of the effect to a precision of 10%.

Обща теория на относителността

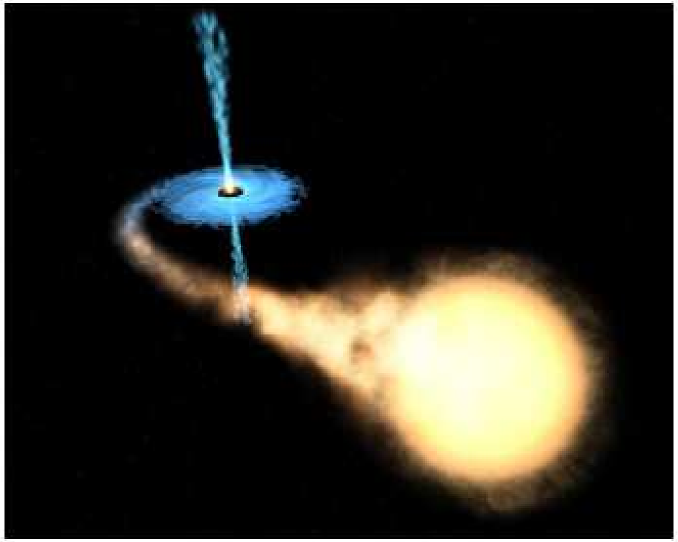
$$R_{ab} - \frac{1}{2}R\, g_{ab} = \frac{8\pi G}{c^4}T_{ab}. \qquad R = R_{cd}g^{cd}$$

$$R_{\alpha\beta} = R^{\rho}{}_{\alpha\rho\beta} = \partial_\rho\Gamma^{\rho}_{\beta\alpha} - \partial_\beta\Gamma^{\rho}_{\rho\alpha} + \Gamma^{\rho}_{\rho\lambda}\Gamma^{\lambda}_{\beta\alpha} - \Gamma^{\rho}_{\beta\lambda}\Gamma^{\lambda}_{\rho\alpha} = 2\Gamma^{\rho}_{\alpha[\beta,\rho]} + 2\Gamma^{\rho}_{\lambda[\rho}\Gamma^{\lambda}_{\beta]\alpha}.$$

$$\Gamma^{i}_{k\ell} = \frac{1}{2}g^{im}\left(\frac{\partial g_{mk}}{\partial x^{\ell}} + \frac{\partial g_{m\ell}}{\partial x^{k}} - \frac{\partial g_{k\ell}}{\partial x^{m}}\right) = \frac{1}{2}g^{im}(g_{mk,\ell} + g_{m\ell,k} - g_{k\ell,m}),$$



Черни дупки



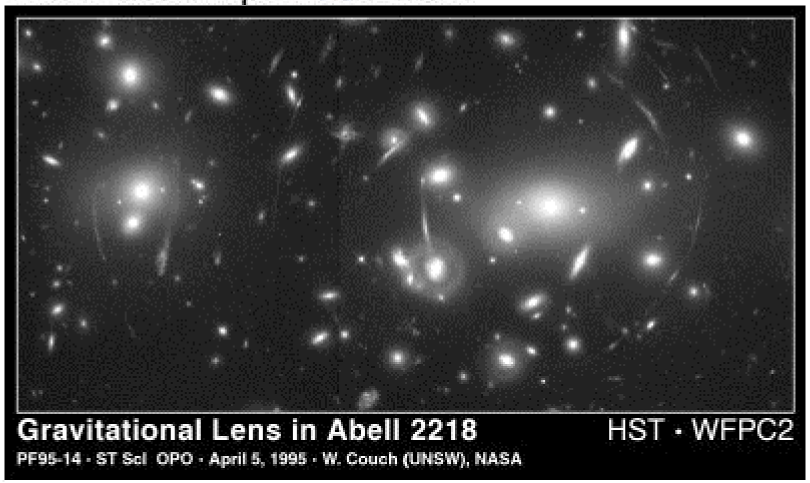
$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

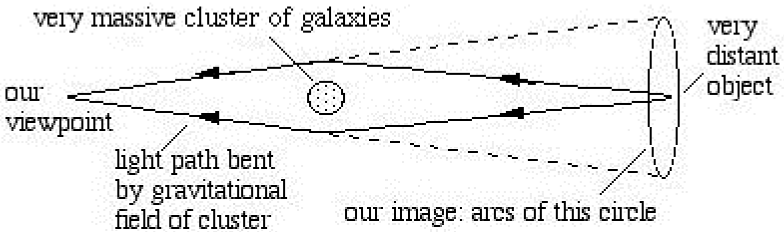
За Земята R_{black} = 9 mm

За Слънцето R_{black} = 3 km

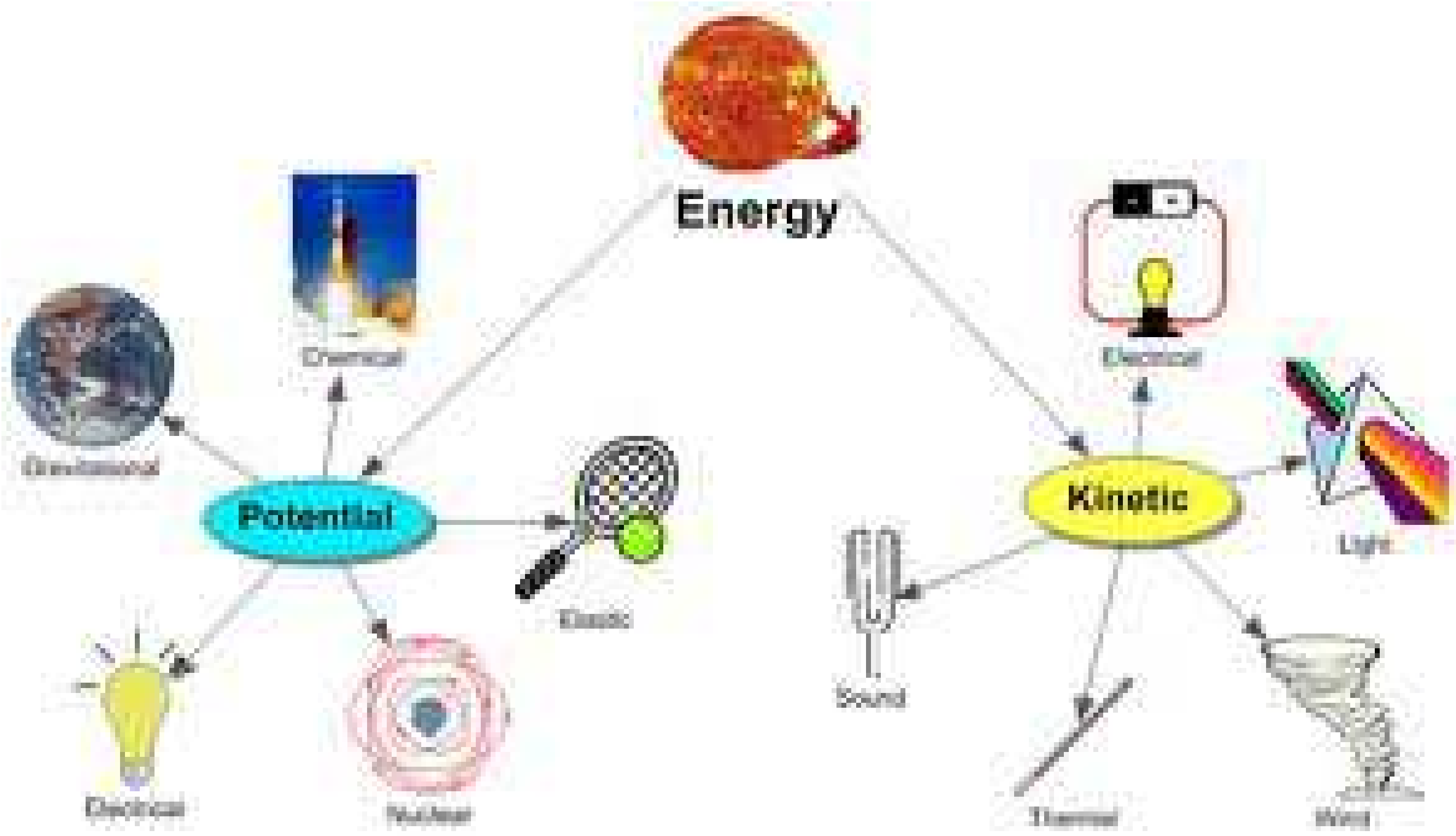
$R_{black} = 2GM/c^2$

a / A black hole accretes matter from a companion star.

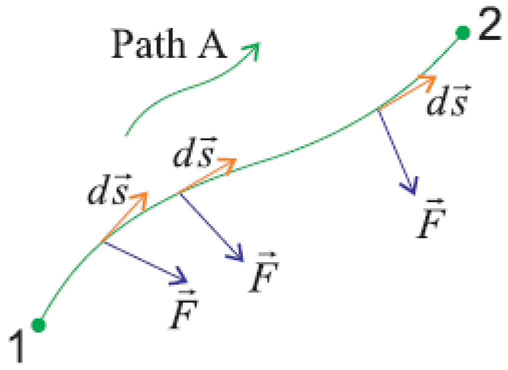




Работа и енергия. Закон за запазване на енергията.



Кинетична и потенциална енергия

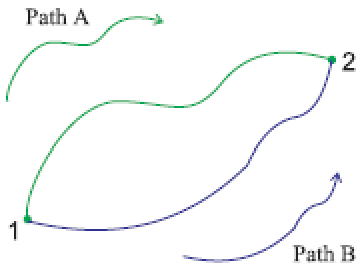


$$dW = \vec{F} \cdot d\vec{s}$$

$$W = \int_{1\,\text{Path A}}^{2} \vec{F} \cdot d\vec{s}$$

Консервативна сила – работата ѝ

по затворен контур е = 0.



$$\int_{1\,\text{Path A}}^{2} \vec{F} \cdot d\vec{s} = \int_{1\,\text{Path B}}^{2} \vec{F} \cdot d\vec{s} \qquad \vec{\nabla} \times \vec{F} = 0$$

Потенциална енергия:

$$dU = -W = -\int \vec{F} \cdot d\vec{s}$$

$$-\Delta W = \Delta U = \int_1^2 dU = U_2 - U_1 = -\int_1^2 \vec{F} \cdot d\vec{s}$$

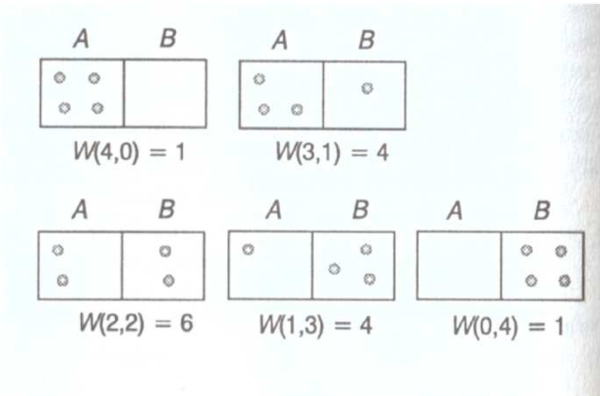
Термодинамика. Принципи на термодинамиката. Ентропия.

$$dU = \delta Q - \delta W, \qquad \delta W = P\,dV,$$

$$\oint \frac{\delta Q}{T} = 0 \qquad \int_L \frac{\delta Q}{T} \qquad dS = \frac{\delta Q}{T}$$

$$S = -k_B \sum_i P_i \ln P_i \,,$$

P_i=1/Ω since Ω is the number of microstates



$$S = k_B \ln \Omega \,,$$

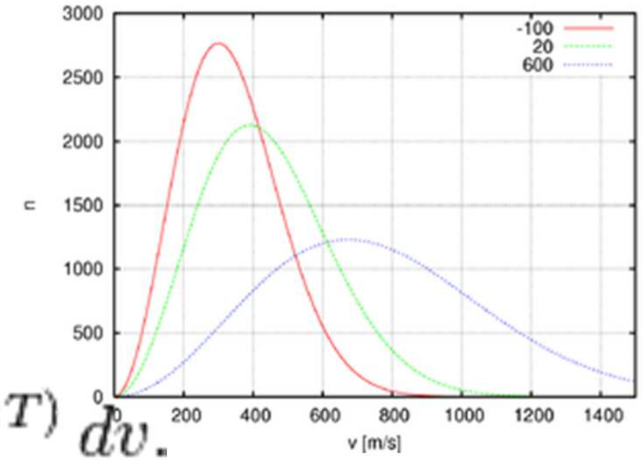
Статистическа механика

$$N_i = \frac{g_i}{e^{(\varepsilon_i-\mu)/kT}} = \frac{N}{Z} g_i e^{-\varepsilon_i/kT}$$

$$E_i = \tfrac{1}{2}mv^2 + mgh$$

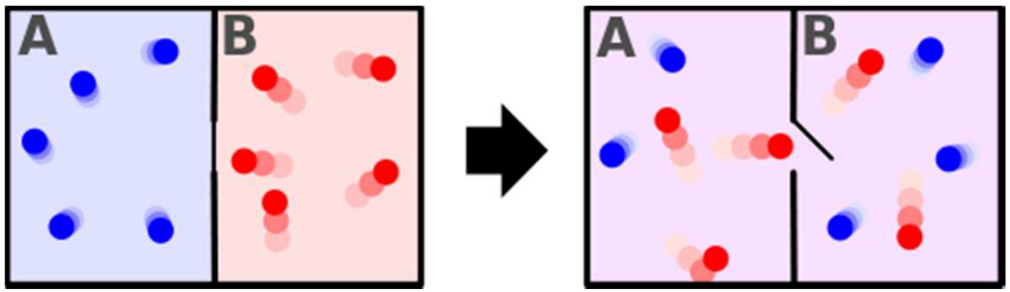
$$N = \sum_i N_i,$$

$$Z = \sum_i g_i e^{-\varepsilon_i/kT}$$



$$D(v)\,dv = \left(\frac{m}{2\pi kT}\right)^{3/2} 4\pi v^2 e^{-mv^2/(2kT)}\,dv.$$

$$\bar{v} = \left(\frac{8kT}{\pi m}\right)^{1/2}.$$




нагревател
Q1
T1
Погълнната топлина за един цикъл
Работно вещество (газ)
A'
Механична работа за един цикъл
Q2
Отдадена топлина за един цикъл
T2
охладител

$$\eta = \frac{A'}{Q'}$$

Отношението на полезната работа A

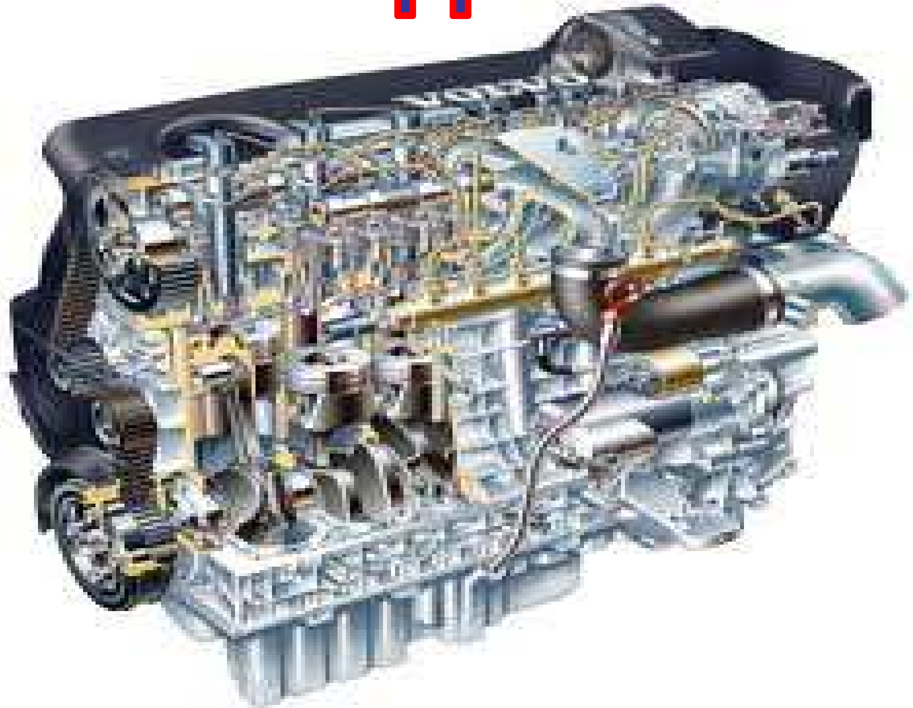
към полученото количество топлина Q

се нарича коефициент на полезото действие (КПД) на топлинната машина

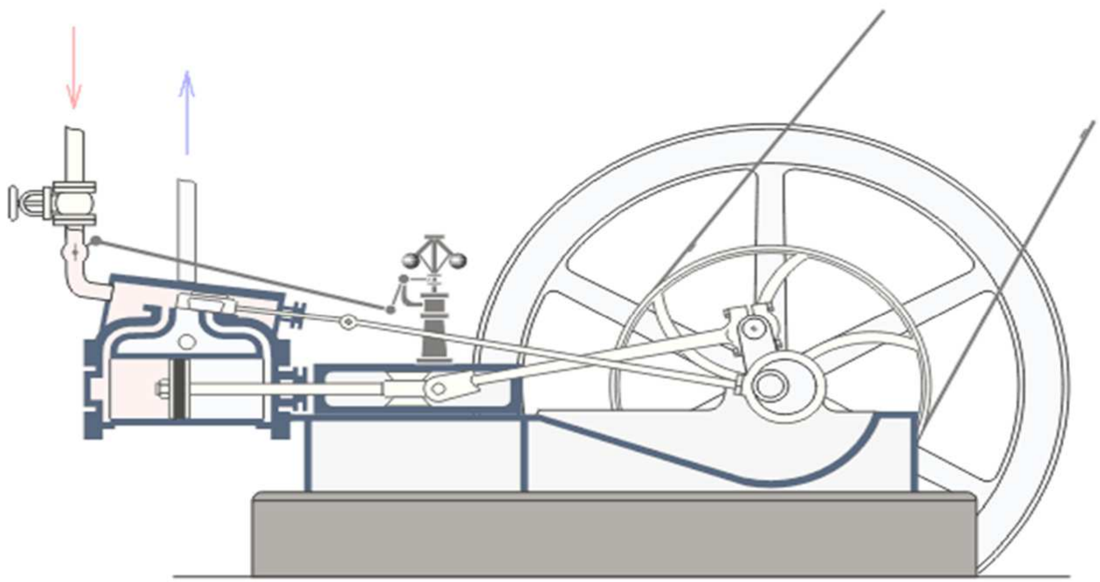
Примери

бензинов двигател

дизелов двигател



парна машина



$\eta = 1$ ←

Такава машина няма да се нуждае от охладител,защото изцяло преобразува полученото от нагревателя количество топлина в работа (Q=A)

II-ри принцип на термодинамиката

Не е възможна топлинна машина, която изцяло да превръща топлината в работа.

За работата на всяка топлинна машина е необходима температурната разлика: на нагревател с по-висока температура T_1 и охладител с по-ниска T_2

Сади Карно

Пръв доказва, че максималният възможен (КПД) на топлинна машина се определя от температурите на нагревателя и охладителя.

$$\eta = 1 - \frac{T_2}{T_1}$$

Идеална топлинна машина

ИЗГОТВИЛА:

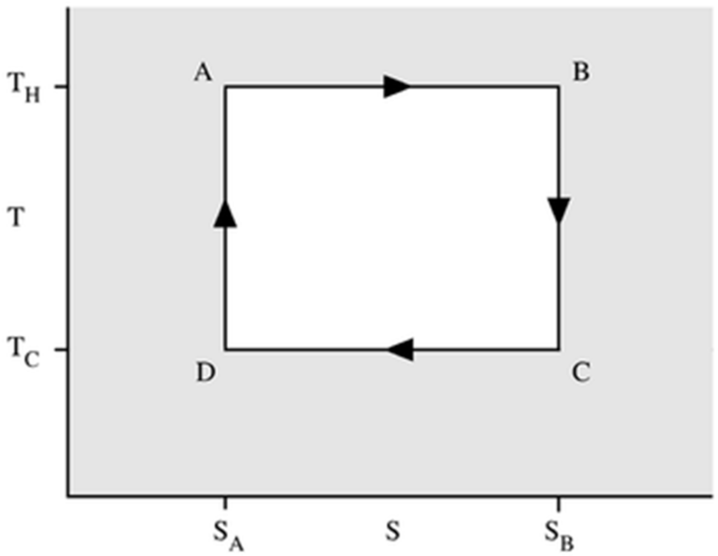
Дана-Мари Таракчиева

VIII А

НУКК

Национален учебен комплекс по култура

2011



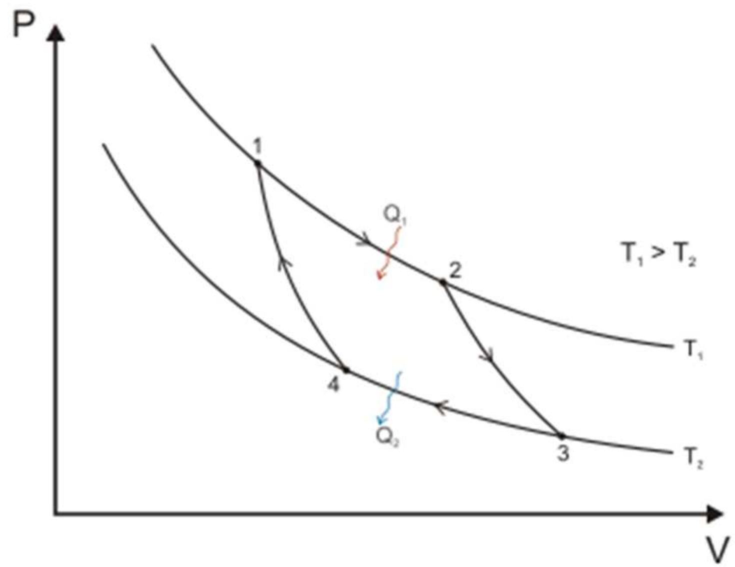
A Carnot cycle acting as a heat engine,

illustrated on a temperature-entropy diagram.

The cycle takes place between a hot reservoir

at temperature T_H and

a cold reservoir at temperature T_C.



A Carnot cycle acting as a heat engine,

illustrated on a pressure-volume diagram

to illustrate the work done