قوانین سه گانه نیوتن:

قانون اول: اگر به جسمی نیروی وارد نشود سرعت جسم تغییر نمی‌کند. (اگر ساکن باشد، ساکن می‌ماند و اگر متحرک باشد با سرعت ثابت به حرکت خود ادامه می‌دهد)

قانون دوم: اگر به جسمی نیروی وارد شود شتابی به آن می‌دهد که با نیرو راستا، هم‌جهت و با جرم جسم رابطه عکس دارد:

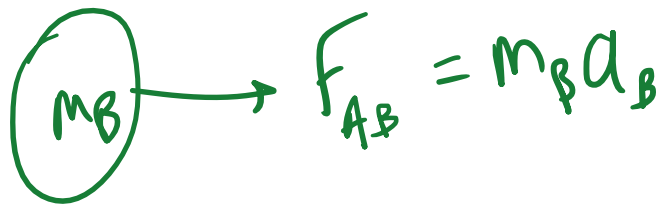
$$a = \frac{F}{m} \qquad (F = ma)$$

قانون سوم: اگر یک جسم به جسم دیگری نیرو وارد کند، جسم دوم نیز نیرویی برابر با همان نیرو ولی در خلاف جهت به آن وارد می‌کند

$$|F_{12}| = |F_{21}|$$

An isolated system is made of two point masses m_A and m_B.
Therefore, the acceleration of each mass is caused only by the force exerted by the other mass, and not by external forces.
Let a_A and F_A be the magnitude of the acceleration and of the net force acting on m_A, and a_B and F_B the magnitude of the acceleration and of the net force acting on m_B.
Then, at every time t,

- A. $a_A = a_B$
- ✓ B. $\frac{a_A}{a_B} = \frac{m_B}{m_A}$
- C. $\frac{a_A}{a_B} = \frac{F_A}{F_B}$
- D. $\frac{a_A}{a_B} = \frac{m_A}{m_B}$
- E. $\frac{a_A}{a_B} = \frac{F_B}{F_A}$



$$|F_{BA}| = |F_{AB}| \Rightarrow m_A a_A = m_B a_B$$

$$\frac{a_A}{a_B} = \frac{m_B}{m_A}$$

A manometer is used to measure

- A. the pressure
- B. a length of order of magnitude $10^{-9}m$
- C. the volumetric flow rate
- D. the density of a liquid
- E. a length in inches

The light reaching us from the stars mostly propagates

- A. through interstellar hydrogen
- B. through interstellar dust clouds
- C. in the ether
- D. through the atmosphere
- E. in vacuum ✓

A temperature of 100° C (degrees Celsius) is equivalent to

- A. $273.15\ K$
- B. $-100\ K$
- C. $373.15\ K$ ✓
- D. $293.15\ K$
- E. $100\ K$

$^\circ C + 273.15 \rightarrow K$

$100 + 273.15 = 373.15\ K$

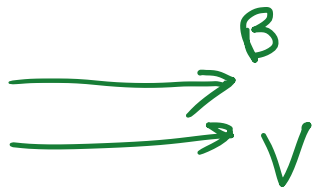
A charged particle is travelling through a magnetic field. Can this particle move on a straight line?

$F = 0$

- A. No, the trajectory is always curved
- B. Yes, but only if the particle starts from rest
- C. Yes, unless the velocity of the particle is parallel to the direction of the magnetic field
- ✓ D. Yes, if the velocity of the particle is parallel to the direction of the magnetic field
- E. Yes, if the velocity of the particle is perpendicular to the direction of the magnetic field

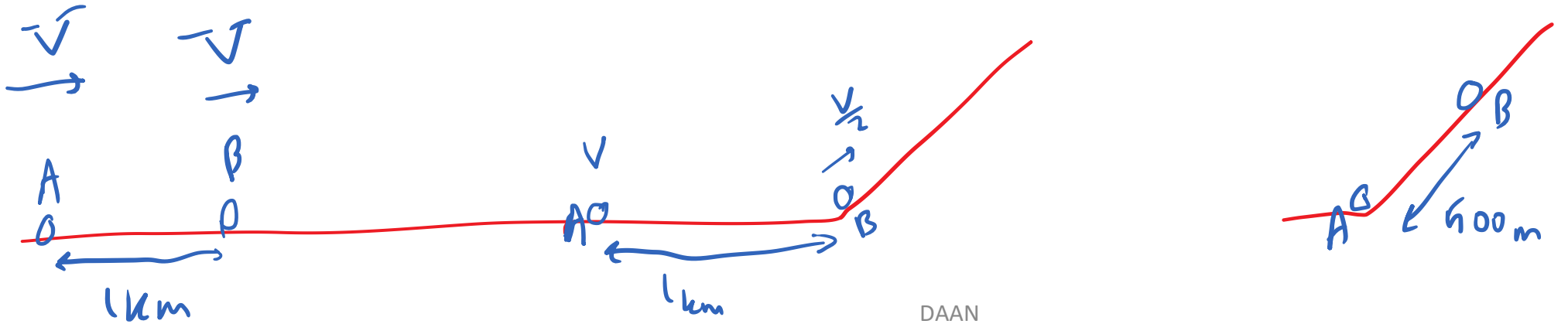
$F = qVB\sin\theta \longrightarrow \sin\theta = 0 \longrightarrow \theta = 0$

B, V زاویه



A cyclist A follows another cyclist B at a distance of $1km$, and the two cyclists proceed at the same speed. Suddenly the road begins to climb with a constant slope. If we assume that both cyclists halve their speed when they start to climb, what is their distance when they both reach the sloping part of the road?

- A. $2km$
- B. $1km$
- ✓ C. $500m$
- D. $250m$
- E. No answer can be given without knowing the initial speed of A and B



A cylindrical container, placed on a horizontal table, is filled with water up to a height of 1 m. At which height should we make a hole, so that the water jet pouring out of the container hits the table at the largest possible distance from the wall of the cylinder? (Assume that water is an ideal fluid)

- A. $0,65\ m$
- B. $0,45\ m$
- C. $0,50\ m$ ✓
- D. $0,25\ m$
- E. $0,75\ m$

In an adiabatic process the internal energy of an ideal gas increases by 2 J. How much work has been done on the gas?

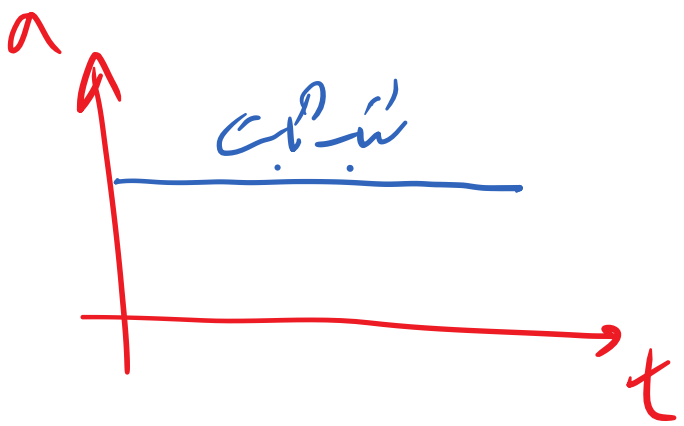
- A. It is impossible to answer without knowing how the pressure varies during the process
- B. It is impossible to answer without knowing how much heat has been exchanged
- ✓ C. 2 J
- D. It is impossible to answer without knowing which type of gas is considered
- E. It is impossible to answer without knowing whether the process is reversible or not

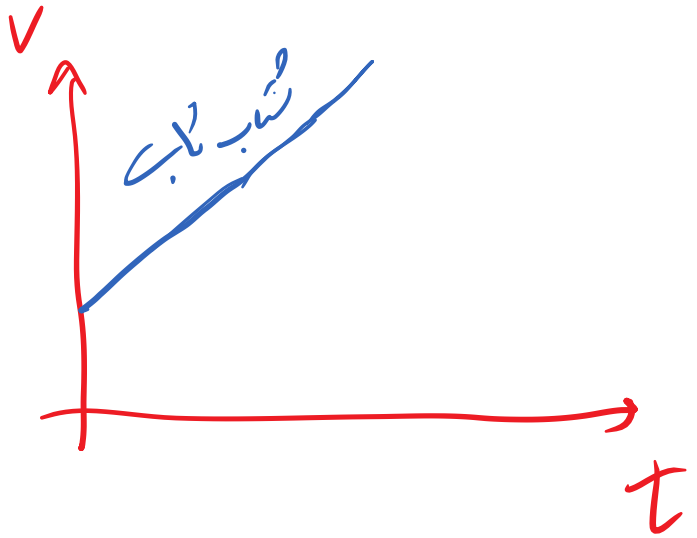
$$\overbrace{\Delta U}^{+2} = \overbrace{Q}^{0} + W \Longrightarrow \boxed{W = 2(J)}$$

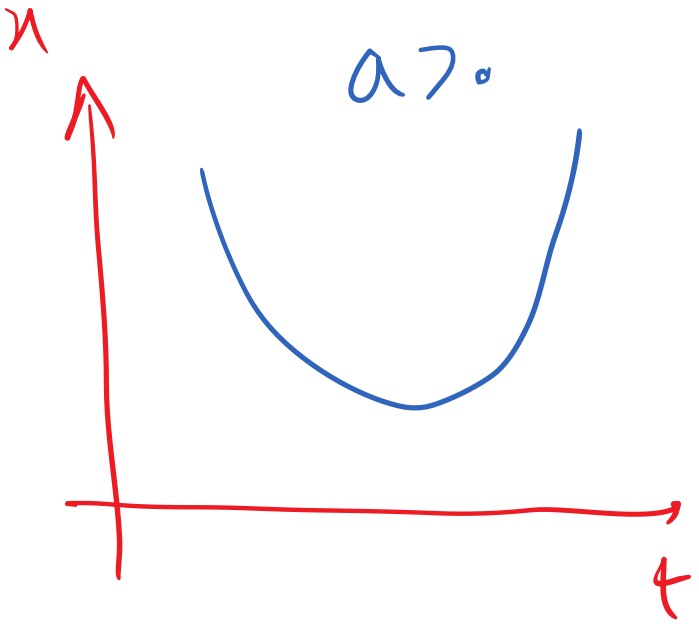
On a graph of displacement versus time, motion along a line with constant acceleration is represented as

جابجایی — بر حسب زمان

- A. a horizontal straight line — خط افقی
- B. a hyperbola — هذلولی
- C. an ellipse — بیضی
- ✓ D. a parabola — سهمی
- E. an inclined straight line — خط مایل







a < 0

A car with a mass of $1600kg$ is moving along a straight line at a constant speed of $108km\,h^{-1}$. How many seconds it takes for the car to stop if it is subjected to a constant braking force of 4000 N?

- A. 75
- ✓ B. 12
- C. 43
- D. 7,5
- E. 0,027

$V = 108 \frac{km}{h} \div 3.6 = 30 \left(\frac{m}{s}\right)$

$F = ma \longrightarrow 4000 = 1600a \longrightarrow a = 2.5 \left(\frac{m}{s^2}\right)$

$V = at + V_0 \longrightarrow 0 = -2.5t + 30 \longrightarrow 2.5t = 30$

$t = \frac{30}{2.5} = 12 \ (s)$

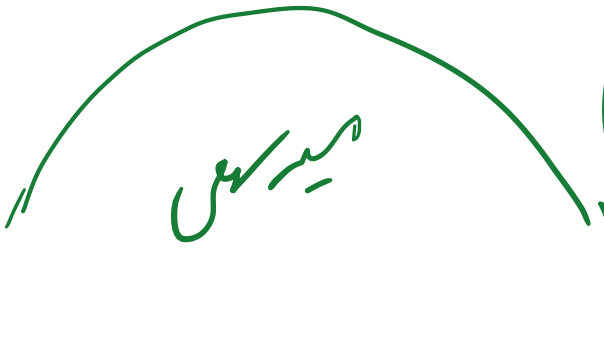
The current that flows in a metallic conductor is due to

- A. the motion of a fluid called electricity
- B. the motion of negative charges (electrons) ✓
- C. the propagation of electromagnetic waves
- D. the motion of positive charges (protons)
- E. the motion of negative charges (electrons) and positive charges (protons) in opposite directions

In a long-jump competition, what is the trajectory of the center of mass of an athlete, if we neglect air friction?

هذلول

- A. an arc of hyperbole
- B. a curve whose shape depends on the speed at the moment of detachment
- C. a curve whose shape depends on the attitude of the athlete's body during the jump
- ✓ D. an arc of parabola سهمی
- E. an arc of ellipse بیضی



$$y = -\frac{1}{2} g t^2 + v_{0y} t$$

$$x = v_{0x} t$$

$$y = ax^2 + bx + c$$

The magnitude of the gravitational field at the surface of the earth is the ratio between the weight and the mass of a body. How is it measured in the International System of Units?

- A. $newton \cdot kilogram$
- B. $newton \cdot metre$
- C. $kilogram - force \cdot kilogram^{-2}$
- ✓ D. $metre \cdot second^{-2}$
- E. $kilogram \cdot metre \cdot second^{-2}$

$g = \frac{W}{m}$

یکای شتاب

$(\frac{m}{s^2})$

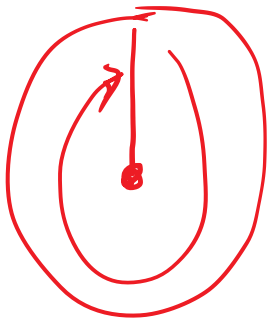
What is the angular speed, measured in rad/s, of the minute hand of a watch?

سرعت زاویه‌ای

- A. $2\pi \times 60$
- ✓ B. $2\pi/60^2$
- C. $2\pi/60^3$
- D. $2\pi/60$
- E. It depends on the length of the hand

$\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{60^2}$

ثانیه



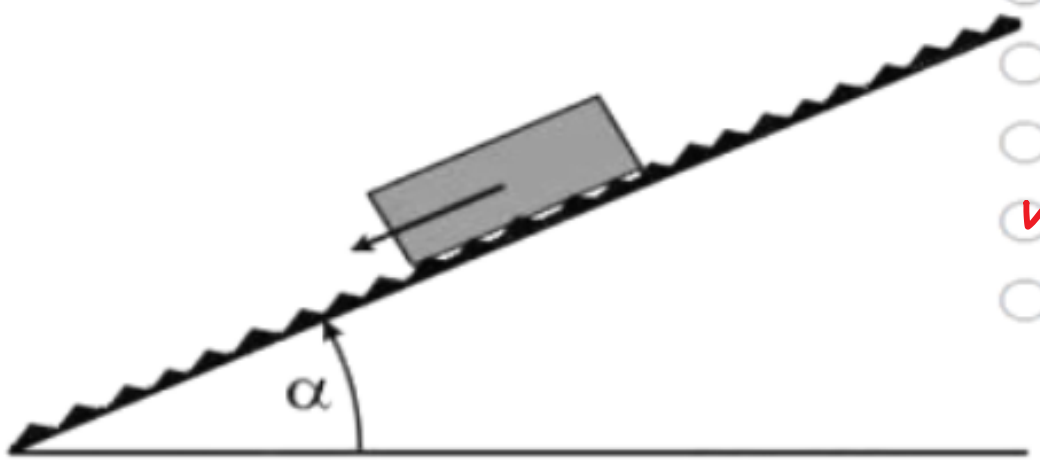
Boyle's law states that at any given temperature the pressure p times the volume V of an ideal gas is constant, namely we can write $pV = c$. The units of the constant c are therefore

فشار × حجم

$\frac{N}{m^2} \times m^3 = N.m$

- A. $\mathrm{N\,m^2}$
- ✓ B. $\mathrm{N\,m}$
- C. $\mathrm{J\,m^3}$
- D. $\mathrm{J\ m^{-3}}$
- E. $\mathrm{J\,m}$

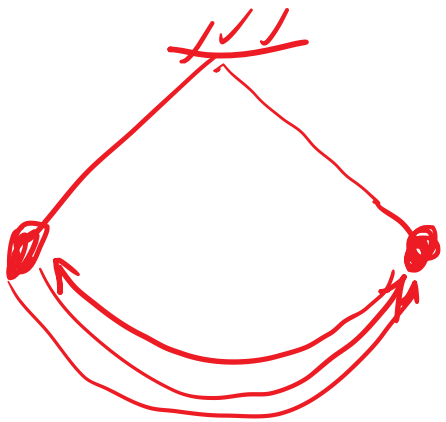
A rigid body stands motionless on a rough incline (with friction). The slope of the incline is progressively increased until the body starts moving. The angle α of the incline with the horizontal at which this happens depends on



- A. the mass of the body
- B. the local value of the gravity acceleration
- C. the contact area between the body and the incline
- D. the coefficient of static friction
- E. the weight of the body

In the absence of friction, would a pendulum put in motion oscillate forever?

- A. No, because the kinetic energy of the pendulum is continuously changing
- B. No, because the motion of a pendulum is not uniform
- C. No, because while the pendulum oscillates its angular momentum changes
- D. Yes, because while the pendulum oscillates its momentum is conserved
- ✓ E. Yes, because while the pendulum oscillates its total mechanical energy does not change



Chemistry

The aim of galvanization (coating with zinc) of an object made of iron is

آہن

- A. increasing its mechanical resistance
- B. giving it a better look
- C. increasing its electrical resistance
- ✓ D. safeguarding it from corrosion
- E. increasing its weight

حفاظت

خوردگی

A salt is formed by the ions Al^{+++} and SO_4^{--}. Its chemical formula is

- A. $Al_2(SO_4)_3$
- B. $Al(SO_4)_3$
- C. $Al_3(SO_4)_2$
- D. Al_3SO_8
- E. Al_2SO_4

2 3

6+ 6−

$Al_2(SO_4)_3$

Which one of the following transformations generates more heat for the same amount of converted substance?

- A. Neutralization of an acid with a base
- B. Freezing of liquid water into ice
- C. Condensation of vapour into liquid water
- D. Combustion of methane with oxygen
- E. Combustion of methanol with oxygen

آرایه الکترون از یک عدد کوانتومی کمتر به یک عدد کوانتومی بالاتر بخواهیم ببریم باید انرژی مصرف کنیم (الکترون برای رفتن
از یک عدد کوانتومی کمتر به یک عدد کوانتومی بالاتر انرژی می‌گیرد)

پس آرایه الکترون از یک عدد کوانتومی بالاتر به یک عدد کوانتومی پایین‌تر برود، انرژی از دست می‌دهد.

Consider the five following electronic transitions in an atom of hydrogen, where n_i represents the initial principal quantum number, and n_f represents the final principal quantum number.

	I	II	III	IV	V
n_i	3	5	4	7	2
n_f	5	3	7	8	7

In which transition does the atom lose energy?

- A. II
- B. III
- C. IV
- D. I
- E. V

Methane, CH_4, burns with oxygen producing CO_2 and H_2O. How many cubic meters of oxygen are needed to burn $1\,m^3$ of methane?

- A. $1,5\ m^3$
- B. $1,0\ m^3$
- C. $3,0\ m^3$
- D. $0,5\ m^3$
- ✓ E. $2,0\ m^3$

$$1CH_4 + 2O_2 \longrightarrow 1CO_2 + 2H_2O$$

An endothermic chemical reaction

- A. yields heat to the surroundings
- B. absorbs heat from the surroundings
- C. leads to an increase of the total number of moles
- D. cannot take place
- E. always takes place in a close container

The electron configuration of an atom of phosphorus is $1s^2 2s^2 2p^6 3s^2 3p^3$. How many electrons does it contain?

- A. 30
- B. 15
- C. 5
- D. 11
- E. 14

Which of the following properties of water (H_2O) is affected by gravity?

- A. Vapour pressure
- B. Melting temperature
- C. Boiling temperature
- D. Density
- ✓ E. Specific weight

→ وزن مخصوص = ρg

The ion H^- has the same electronic configuration as an atom of

- ✓ A. He — دو الکترون دارد
- B. Xe
- C. Ar
- D. Ne
- E. Kr

$H \rightarrow$ یک الکترون

$H^- \rightarrow$ دو الکترون

Which one of the following chemical elements is an alkali metal?

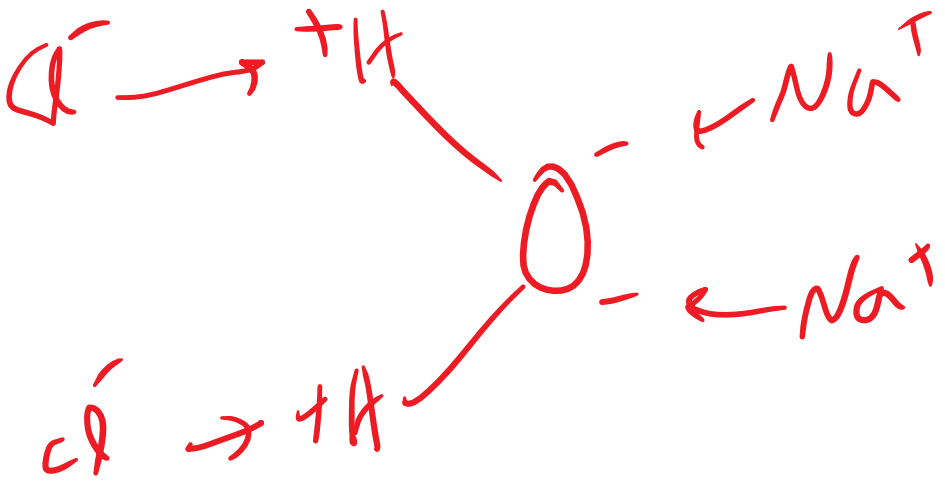
- A. Silver
- B. Aluminium
- C. Fluorine
- D. Uranium
- ✓ E. Sodium

H
Li
Na
K
Rb
Cs
Fr

فلز قلیایی
↓
عناصر ستون اول جدول تندی به جز هیدروژن

The salt typically used for cooking - NaCl - dissolves easily in water because

- A. the atoms Na and Cl are produced in water
- ✓ B. the ions Na^+ and Cl^- are strongly attracted by the molecules of water
- C. it reacts with water to produce HCl and NaOH, which are soluble
- D. the molecules of water have a greater kinetic energy than salt
- E. it melts into a liquid



To induce the chemical change $O_2 \rightarrow 2O$ we must

- A. subtract energy
- B. supply energy ✓
- C. lower the temperature
- D. decrease the volume
- E. increase pressure

1g of NaCl dissolves into one litre of distilled and degassed water. The pH of the solution is

- A. negative
- B. greater than the pH of water
- C. greater or less than the pH of water, depending on the temperature
- D. less than the pH of water
- ✓ E. basically equal to the pH of water

Which one of the following elements is a solid at room pressure and temperature?

- A. Neon
- B. Magnesium
- C. Bromine
- D. Hydrogen
- E. Mercury