14 years

T: The DNA molecule is made up of two polynucleotide chains that spirally wrap around each other. Each chain consists of a large number of nucleotides, and each nucleotide consists of a nitrogenous base, a deoxyribose sugar and a phosphate group. There are four nitrogenous bases in the DNA molecule: adenine (A), guanine (G), cytosine (C) and thymine (T).
Between the two chains, each base can be paired with the complementary base of the other chain in such a way that adenine is always paired with thymine and vice versa, and cytosine is always paired with guanine and vice versa. In this way, we get possible combinations: A+T, T+A, C+G, G+C.

Q: Sune found that one piece of evidence has the sequence of nucleotides in one strand ACGGTATCC, but to go further she needs to determine its complementary strand. It is:

1	ACGGTATCC
2	CCTATGGCA
3	GTAACGCTT
4	**TGCCATAGG**

15 years

Viruses and bacteria

T: The causative agents of many diseases are viruses and bacteria.
Viruses affect our health. Their size is from 2 - 30 nm, and they are transmitted through the air - by droplet, by touch or by other organisms. Viral diseases are most often treated by vaccination.
Bacteria are larger than viruses, they are 0.001 mm in size. Diseases are caused by pathogenic bacteria, and bacteria are treated with antibiotics. There are also bacteria that live in the human body.

Q: Sune found broken test tubes in the laboratory. Some contained viruses, some bacteria. He is at risk of infection. For which diseases listed in the table will have to be vaccinated?

H: Consider whether diseases are treated with vaccination or antibiotics.

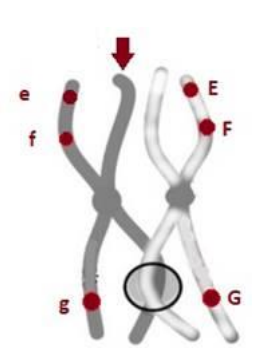| Streptococcal angina	COVID	HPV	Echerihia Coli	Tuberculosis	Ebola	Zika
1	2	3	4	5	6	7

1	2, 3, 5
2	**2, 3, 6, 7**
3	1, 4, 5
4	2, 4, 6

16 years

T: In prophase I, chromosomes form from chromatin and pairing of homologous chromosomes occurs. Homologous chromosomes are chromosomes that are the same size and shape and carry genes for the same characteristics in the same place.
During prophase I, homologous chromosomes can exchange parts of the chromatid with each other, and thus the genes located on those parts of the chromatid. This process is called crossing over.

Q: The picture shows one homologous pair of chromosomes in prophase I of meiosis. Which sequence of gene variants (alleles) after chromatid exchange will have a chromatid marked with an arrow?

1	Efg
2	EFg
3	eFg
4	**efG**

17 years

Mutations

T: During the evolution of man, many mutations occurred, but mutations still occur today. Mutations are changes in the genetic material of a cell. The causes of their formation can be spontaneous biological or induced by mutagens. A mutagen is, for example, X-ray radiation. Chromosome mutation occurs more often in humans.
If the number of chromosomes increases by 1 (2n+1), Down's syndrome occurs, if it decreases by one (2n-1), Turner's syndrome occurs.

Q: In the laboratory, Sune also found test tubes with different inscriptions - sperm and egg chromosomes. You should only take the one with the combination for a girl with Down syndrome. What combination is that?

H: Remember whose sex chromosome is responsible for the sex of the child.

1	22AY and 22AX
2	**23AX and 23AX**
3	22AX and 23AY
4	23AX and 23AY

14 years

The empirical formula expresses the smallest possible ratio of the number of atoms of the elements in the compound:

$$N(X):N(Y) = \frac{w(X)}{A_r(X)}:\frac{w(Y)}{A_r(Y)} = \frac{m(X)}{A_r(X)}:\frac{m(Y)}{A_r(Y)}$$

where X and Y are the elements of the compound, w is the mass fraction, m is the mass of the individual element [g], A_r is the relative atomic mass, and the final appearance of the formula $X_{N(X)}Y_{N(Y)}$.

The mass fraction of an ingredient in a mixture or solution is equal to the ratio of the mass of that ingredient to the total mass of the mixture or solution:

$$m(X) = w(X) * 100\ g$$

Relative atomic mass can be found in the periodic table of elements.

Q: Sune found some dark red solution in a test tube in the closet. By elemental analysis of the compound of that solution, she determined that w(C)= 60%, a w(H)=10%. What is the empirical formula of the compound?

1	C_2H
2	C_2H_2
3	CH_2
4	CH

15 years

Molality -b(X) is expressed by the ratio of the mass of the dissolved substance -n(X) and the mass of the solvent -m(solvent):
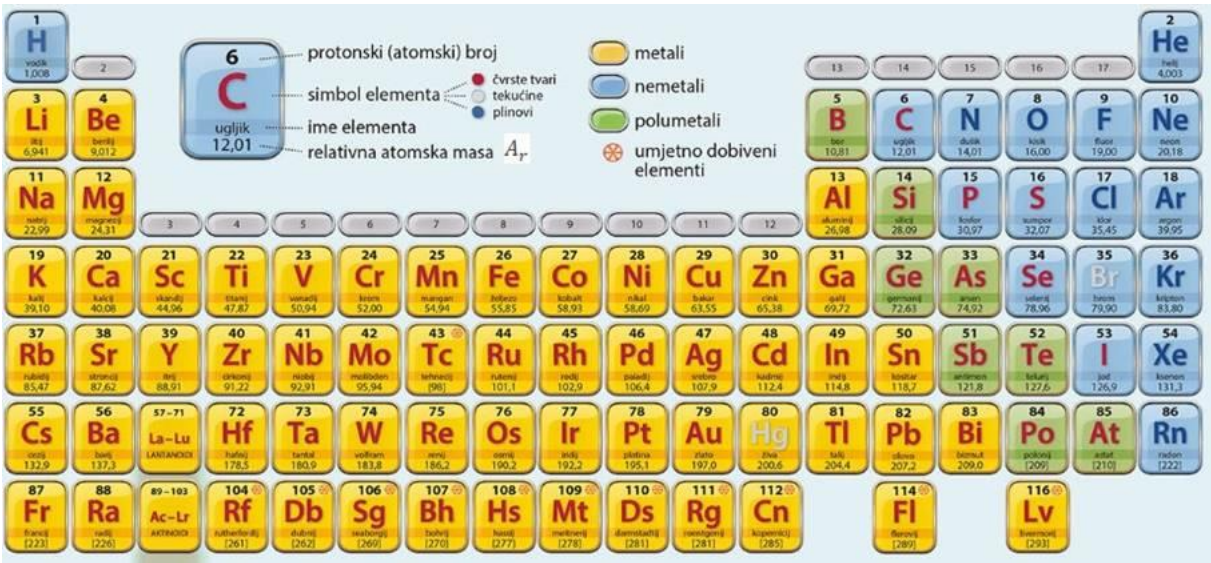
$$b(X) = \frac{n(X)}{m(\text{solvent})}$$

where is

$$n(X) = \frac{m(X)}{M(X)}$$

The unit for molality is mol/kg.
M(X) is the sum of all the relative atomic masses (A_r) of the elements that make up the compound (X). A solvent is a liquid that can dissolve different ingredients, for example water.
The formula for calculating the density is

$$\rho(\text{solvent}) = \frac{m(\text{solvent})}{V(solvent)}$$

where ρ represents density [g/cm^3], m mass [kg], and V volume [L or cm^3 or kg].

Relative atomic mass can be found in the periodic table of elements.

Q: Sune found an Erlenmeyer flask with 1 L of water in the closet. She put 100 g of table salt in it, which dissolved. What is the molality of the resulting solution? $\rho(H_2O) = 1\ g/cm^3$)

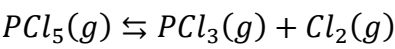| 1 | 0,171 mol/kg |
2	17,1 mol/kg
3	**1,71 mol/kg**
4	0,0171 mol/kg

16 years

T: The equilibrium pressure constant (K_p, [bar]) is related to the equilibrium concentration constant (K_c,[mol/dm^3]) by the following expression:

$$K_p = K_c * (R * T)^{\Delta n}$$

where =8.314*10^3 $\frac{Pa*dm^3}{mol*K}$, temperature [K], n is the difference between the sum of the stoichiometric numbers of the products and the sum of the stoichiometric numbers of the reactants.

The stoichiometric number (v) is the number that appears in front of the formula of each compound in the chemical reaction equation. If no number is written in front of the formula, then it is 1.

Q: Calculate the value of the pressure constant for the following reaction if the equilibrium concentration constant is 10^{-2} mol/dm^3 pri 489 K.

$$PCl_5(g) \leftrightarrows PCl_3(g) + Cl_2(g)$$

1	72,773 Pa
2	7277 Pa
3	**72 773 Pa**
4	0,72773 Pa

17 years

T:
Corrosion is a natural process that results from the wear and tear of construction material. It is caused by physical, chemical or a combination of physical and chemical processes.
The surface can be partially or completely affected. The characteristic color by which we recognize corrosion is red-brown rust, but also the blue-green platinum of copper monuments.
The damage caused by corrosion is great, and it is estimated that up to 4% of the gross domestic product of developed countries goes to the costs caused by corrosion.
Ways of corrosion protection are: cathodic (current protection), anodic (tin coating), galvanization (zinc coating). Almost all methods of corrosion protection pollute the environment, and many laws are currently in force for the purpose of environmental protection.

Q: Which of the materials are resistant to corrosion?

1	Iron, aluminum, nickel
2	Aluminum, nickel, gold
3	**Nickel, gold, tin**

4	Gold, platinum, copper

14 YEARS

HINT

Rectangular projection is a drawing of the one side of some object using their two dimensions. Most common projections are front view (N), side view (B) and ground plan (T).
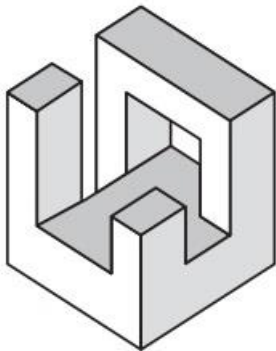
Front view is view that we choose as a front.

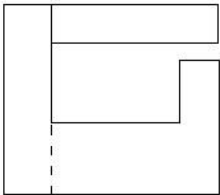Side view is view on the left of the front view.

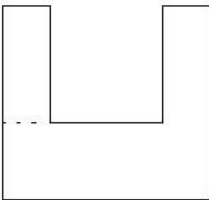Ground plan is a view from the above.

QUESTION

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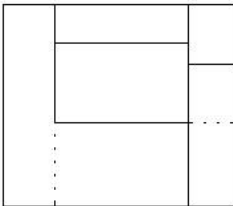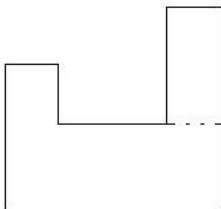
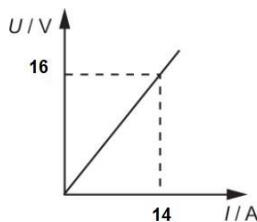1.   2.   **3.**   4.

15 YEARS

HINT

Basic circuit is consisted of a resistance (R), voltage U [V] and electricity I [A]. Each circuit is based on a Ohm's law that states that the current through a conductor between two points is directly proportional to the voltage across the two points:

$$I = \frac{U}{R}$$

QUESTION

To turn on the electricity without causing a malfunction Sune needs to calculate the resistance based on the graph on the picture. After the calculation Sune will connect the circuit on a new voltage source U= 24 V. She needs to calculate the total electricity based on the new voltage and resistance that she already has calculated.

1. 1,143 A
2. 14 A
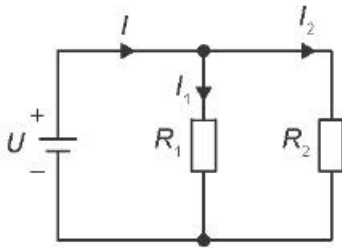3. **20,99 A**
4. 21,015 A

16 YEARS

HINT

In a parallel circuit of the resistors, ratio of the electricity $I[A]$ through the resistors is inversely proportional to their resistance $R[\Omega]$. If we know the value of the resistors R_1 and R_2, total electricity I and voltage $U[V]$ then we can calculate I_1 and I_2 using the following expressions:

$$I_1 = \frac{U}{R_1} = \frac{I * R_2}{R_1 + R_2} \qquad I_2 = \frac{U}{R_2} = \frac{I * R_1}{R_1 + R_2} \qquad I = \frac{U}{R} \qquad R = \frac{R_1 * R_2}{R_1 + R_2}$$

QUESTION

For the parallel circuit of the resistors where $R_1 = 4\Omega$ and R_2 is unknow Sune needs to calculate the electricity I_2. The total electricity is $I = 8\,A$ and the total voltage is $U = 24\,V$.

1. 12 A
2. 7 A
3. 2 A
4. 24 A

17 YEARS

HINT

Sune noticed that the lightbulb on the celling is flickering. To find out what the problem is she has to calculate the current value of the alternating voltage. To get that value first she has to writ3e the expression using the next formula
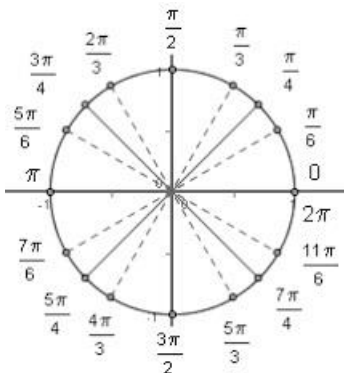
$$u(t) = U_m \sin(\omega t + \varphi)$$

Where U_m is the maximum value of the current voltage [V], U is the effective value of the voltage [V], ω circular frequency [rad/s], t time[s], a φ starting angle [rad].

The rest of the formulas that she must use are:

$$U_m = \sqrt{2} * U \quad \omega = \frac{2\pi}{T} \quad f = \frac{1}{T}$$

where T is the duration of one time period [s], and f is frequency [Hz].

QUESTION

If the effective value of the voltage is 220 V, frequency 0,05 kHz, starting angle 30°, and time 10 ms, what's the current value of the voltage $u(t)$?

1. -1,394 V
2. 1,414 V
3. 0,09 V
4. -0, 523 V

14 YEARS

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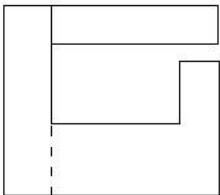Side view is view on the left of the front view.

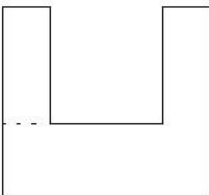Ground plan is a view from the above.

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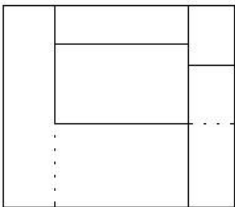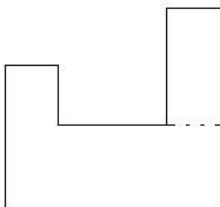

2.   2.   **3.**   4.
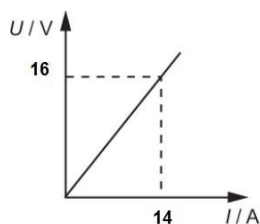
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6. 14 A
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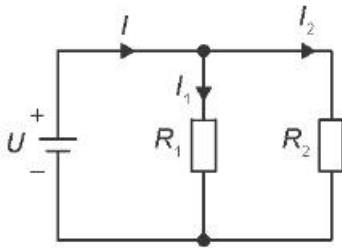8. 21,015 A

16 YEARS

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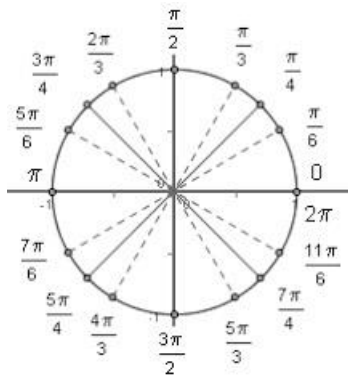
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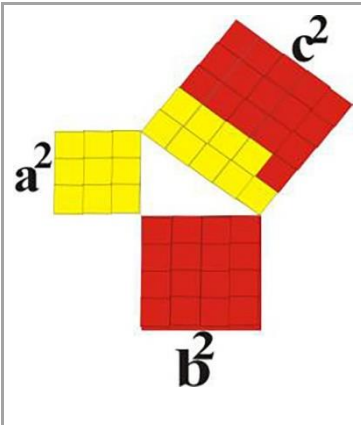where T is the duration of one time period [s], and f is frequency [Hz].

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14 years

T:

	Pythagoras' lesson Right triangle • Two sides are called legs (a and b), and the third (longest) hypotenuse (c) • Opposite the hypotenuse is the largest angle - a right angle (90°) • The sum of the other two angles α and β is 90° • Pythagoras' lesson: the sum of the squares of the length of the legs is equal to the square of the length of the hypotenuse, that is, $a^2 + b^2 = c^2$. • The center of the described circle is in the middle of the hypotenuse • The radius of the circle described by the right triangle is equal to half the length of the hypotenuse • Area of a right triangle $P = \frac{a \cdot b}{2}$ ili $P = \frac{c \cdot v_c}{2}$

Q: Sune entered the laboratory and saw a cabinet in the middle. The cabinet is 1.2 m high. Determine the shadow of the cabinet when Sune is standing next to it. Sune is 1.85 cm tall, and her shadow is 2.10 m long.

H: Draw right triangles and mark the required sizes.

1	1,06 m
2	1,36 m

3	3,23 m
4	1,45 m

15 years

T:

The bisector of a length (side) is a line that passes through the middle of the length and is perpendicular to it. The bisector of an angle is the line that bisects the angle and passes through its apex. The height of a triangle is the length that lies on the line that passes through the vertex and is perpendicular to the opposite side. The centroid is the length that connects the apex of the triangle with the midpoint of the opposite side. The median of a triangle is the length that joins the midpoints of the two sides of the triangle.

Four characteristic points of a triangle:
1. The center of the circumscribed circle of the triangle is located at the intersection of the bisectors of the sides.
2. The center of the inscribed circle of the triangle is located at the intersection of the angle bisectors.
3. The orthocenter of the triangle is located at the intersection of the altitudes of the triangle.
4. The center of gravity of the triangle is located at the intersection of the centroids of the triangle. It divides the center of gravity in the ratio 2:1 from the top to the page.

Formulas:

$$P = \frac{abc}{4R}, \qquad P = rs$$

Q: Three pieces of evidence are 13 m, 14 m, and 15 m apart. At what distance from the piece of evidence should the chair be placed so that it is equidistant from each piece of evidence?
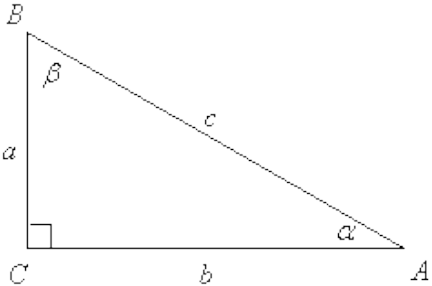
H: Draw triangle and mark the required sizes.

1	4 m
2	8,125 m
3	0,25 m
4	0,125 m

16 years

Trigonometric ratios

T: We use trigonometric ratios in a right triangle.

	Trigonometric ratios in a right triangle: $$\sin \alpha = \frac{the\ length\ of\ the\ opposite\ leg}{the\ length\ of\ the\ hypotenuse}$$ $$\cos \alpha = \frac{length\ of\ adjacent\ leg}{the\ length\ of\ the\ hypotenuse}$$ $$tg\ \alpha = \frac{the\ length\ of\ the\ opposite\ leg}{length\ of\ adjacent\ leg}$$ $$ctg\ \alpha = \frac{length\ of\ adjacent\ leg}{the\ length\ of\ the\ opposite\ leg}$$
	$$\alpha + \beta = 90^\circ$$ $$\sin \alpha = \cos(90° - \alpha) = \cos \beta$$

Q: If the highest shelf from the door is seen at an angle of 56°, and when we move 1.2 meters inward, the highest shelf is seen at an angle of 70°. At what height is the highest shelf inside the laboratory?

H: Draw triangle and mark the required sizes.

1	0,71 m
2	1,41 m
3	2,38 m
4	0,42 m

17 years

T: Cosine lesson

The cosine lesson is one of the fundamental lessons in mathematics. We use it in an isosceles triangle to calculate the length of a side or the measure of an angle.
1. Two sides and the angle between them (SAS)
If we know the lengths of two sides and the measure of the angle between them in an equilateral triangle, we can calculate the length of the third side, and then the measures of the remaining unknown angles. Valid:

$c^2 = a^2 + b^2 - 2abcos\gamma.$

Analogously, it also applies to the remaining pages.

2. Three pages (PPP)
If we know the lengths of all three sides of an isosceles triangle, we can calculate the measure of one angle, and then the measures of the remaining angles.

$$\cos\gamma = \frac{a^2 + b^2 - c^2}{2ab}$$
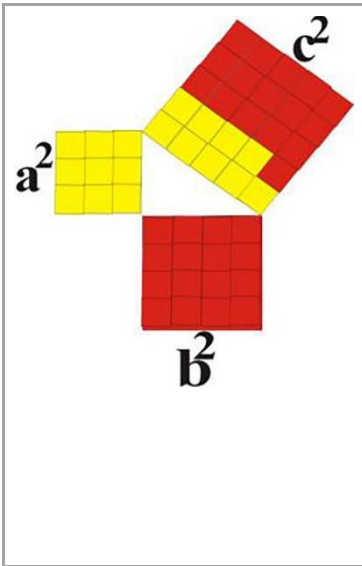
Analogously, it also applies to the remaining angles.

Q: The distance between evidence A and B Suna cannot measure directly. Sune knows that evidence A is 1.5 m from evidence C, and evidence B is 1.4 m from evidence C, and that the angle between the distance AC and BC is 53°7'48". What is the distance between proofs A and B?

H: Draw triangle and mark the required sizes.

1	1,1 m
2	1,3 m
3	1,2 m
4	1 m

14 years

T:

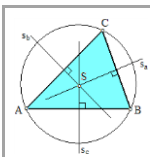|	Pythagoras' lesson
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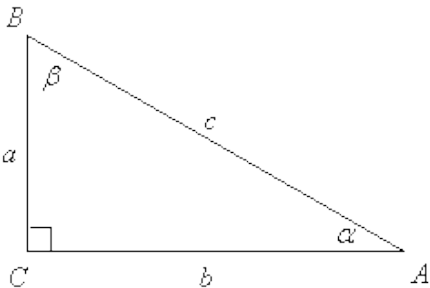
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$$\cos\gamma = \frac{a^2 + b^2 - c^2}{2ab}$$

Analogously, it also applies to the remaining angles.

Q: The distance between evidence A and B Suna cannot measure directly. Sune knows that evidence A is 1.5 m from evidence C, and evidence B is 1.4 m from evidence C, and that the angle between the distance AC and BC is 53°7'48". What is the distance between proofs A and B?

H: Draw triangle and mark the required sizes.

1	1,1 m
2	1,3 m
3	1,2 m
4	1 m