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Maplesoft™, a subsidiary of Cybernet Systems Co. Ltd. in Japan, is the leading provider of high-performance software tools for engineering, science, and mathematics. Its product suite reflects the philosophy that given great tools, people can do great things. Learn more about Maplesoft. Let f be a polynomial with integer coefficients in one or more variables. An algebraic equation of the form$$f(x_1, x_2, …, x_n) = 0,$$whose roots are required to be integers, is called a Diophantine equation.The simplest equations are linear Diophantine equations of the form$$a_1x_1 + a_2x_2 + … + a_nx_n = m,$$where $a_1, a_2, …, a_n, m \in \mathbb{Z}$.Linear Diophantine equationIn more detail, we will observe a linear Diophantine equation in two variables, x and y:$$ax + by = c; \quad a, b, c \in \mathbb{Z}.$$First of all, we will show how to solve a homogeneous linear Diophantine equation $ax + by = 0$, by using the following example.Example 1. Find all integer solutions of the following equation:$$2x – 3y = 0.$$Solution. The given equation we write in the form:$$y = \frac{2x}{3}.$$Since y must be an integer, and how 2 and 3 are relatively prime numbers, that x must be a multiple of 3. Therefore, $x = 3k$, where $k \in \mathbb{Z}$. If we include it in the given equation, we will obtain $y = 2k, k \in \mathbb{Z}$. Therefore,$$x = 3 k, \quad y = 2 k, \quad k \in \mathbb{Z},$$is the set of all solutions of the given equation. We can see that the equation has infinitely many solutions.In general, if we have the equation$$ax + by = 0, \quad a^2 + b^2 eq 0,$$then$$x = – \frac{by}{a},$$from where it follows $y = – at, t \in \mathbb{Z}$ and $x = bt, t \in \mathbb{Z}$. Therefore, with $x = bt$ and $y = – at, t \in \mathbb{Z}$ is given the set of all integer solutions of the equation $ax + by = 0$.We can show now how to solve a non-homogeneous linear Diophantine equation in two variables $ax + by = c, c eq 0$. The basic idea of solving these equation it consists in the fact that we solve its associated homogeneous linear equation $ax + by = 0$. Consider the following example.Example 2. Solve the following Diophantine equation:$$7x – 9y = 3.$$Solution.First of all, we will find any integer solution of the given equation. Such a solution surely exists because $\gcd(7, 9) = 1$ and 3 is divisible by 1. One solution of the given equation is $x_0 = 3, y_0 = 2$. Any concrete solution of the equation is called a particular solution. Therefore, $x_0 = 3, y_0 = 2$ is one particular solution of the given equation, so the following is valid:$$7x_0 – 9 y_ 0 = 3.$$If from the given equation we subtract the previous equality, we will obtain the following:$$7(x – x_0) – 9 (y -y_0) = 0,$$and that is a homogeneous linear equation. Its solution is:$$x – x_0 = 9 t, \quad y – y_0 = 7t, $$that is,$$x = 9t + x_0, \quad y = 7t + y_0.$$Substituting x_0 and y_0 to the solution of a homogeneous equation, we obtain all integer solutions of the given equation:$$x = 3 + 9t, \quad y = 2 + 7t, \quad t \in \mathbb{Z}.$$In general, solution of the non-homogeneous linear Diophantine equation is equal to the integer solution of its associated homogeneous linear equation plus any particular integer solution of the non-homogeneous linear equation, what is given in the form of a theorem. We write:$$x = x_0 + bt, \quad y = y_0 – at, \quad t \in \mathbb{Z}.$$However, there appears a problem, that is, the question of whether each of the linear Diophantine equation has integer solutions. For example, the equation $4x + 2y = 13$ has no integer solutions because its left side is an even number, $\forall x, y \in \mathbb{Z}$, and its right side is an odd number, so, there are no integers x and y that satisfy the specified equation.Therefore, we must first determine the requirement with which a linear Diophantine equation has integer solutions.The following theorem gives us a condition of resolvability of Diophantine equations.Theorem 1. The equation $ax + by = c$, $a^2 + b^2 eq 0$, $a, b, c \in \mathbb{Z}$ has integer solution if and only if $\gcd(a, b) | c$.To search for the greatest common measure of two numbers, we use the Euclidean algorithm, and it relies on the divisibility theorem:For $a \in \mathbb{Z}$ and $b \in \mathbb{N}$ there exist unique integers q and r such that $a = bq + r$ and $0 \le r < b$.The number q is called the quotient and r is called the remainder. The quotient and remainder defined by the theorem above are unique. If the remainder is 0, then $a = bq$, therefore, by the definition of divisibility, b divides a.Now we are going to write a scheme of the Euclidean algorithm. On the left of the page we will indicate the ordered pairs of numbers to which we will apply the equality from the divisibility theorem:$$(a, b),   a = bq_1 + r_1, r_1 < b $$$$(b, r_1), b = r_1 q_2 + r_2   r_2 < r_1$$$$(r_1, r_2), r_1 = r_2 q_3 + r_3,   r_3 < r_2$$$$(r_3, r_3), r_2 = r_3q_4 + r_4, r_4 < r_3 $$$$\vdots $$$$(r_{k-2}, r_{k-1}), r_{k-2} = r_{k-1}q_k + r_k, r_k

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