

I'm not a robot



Error detection for identification numbers A check digit is a form of redundancy check used for error detection on identification numbers, such as bank account numbers, which are used in an application where they will at least sometimes be input manually. It is analogous to a binary parity bit used to check for errors in computer-generated data. It consists of one or more digits (or letters) computed by an algorithm from the other digits (or letters) in the sequence input.[1] With a check digit, one can detect simple errors in the input of a series of characters (usually digits) such as a single mistyped digit or some permutations of two successive digits. Check digit algorithms are generally designed to capture human transcription errors, in order of complexity, these include the following:[2] letter/digit errors, such as $1 \rightarrow O$ or $O \rightarrow 0$ single-digit errors, such as $1 \rightarrow 2$ transposition errors, such as $11 \rightarrow 21$ twin errors, such as $131 \rightarrow 231$ jump twin errors, such as $131 \rightarrow 232$ phonetic errors, such as $60 \rightarrow 16$ ("sixty" to "sixteen") In choosing a system, a high probability of catching errors is traded off against implementation difficulty; simple check digit systems are easily understood and implemented by humans but do not catch as many errors as complex ones, which require sophisticated programs to implement. A desirable feature is that left-padding with zeros should not change the check digit. This is because any variable length system must be used and the length to be changed. If there is a single check digit added to the original number, the system will not always capture multiple errors, such as two replacement errors, which typically, double errors would be caught if the system had the ability to detect them. A single check digit modulo would be to add the result of all the digits (digital sum) modulo 10, with a weight of 1 for each digit. This is because the sum of the digits, modulo 10, with different weights for each number position, will change this, for example, if the weights for a four digit number were 5, 3, 2, 7 and the remainder to be checked was 4, 8711. The digital sum would take $5 \times 4 + 3 \times 8 + 2 \times 7 + 7 \times 1 = 65$, i.e. 65 modulo 10, and the check digit would be 5, giving 48715. Systems with weights of 1, 3, 7, or 9, with the weights on neighboring numbers being different, are widely used, for example, 31, 31 weights in UPC codes, 13, 13 weights in EAN numbers (GS1 algorithm), and the 371, 371, 371 weights used in United States bank routing transit numbers. This system detects all single-digit errors and around 90% [citation needed] of transposition errors. 1, 3, 7, and 9 are used because they are coprime with 10, so changing any digit changes the check digit, using a coefficient that is divisible by 2 or 5 would lose information (because $5 \times 0 = 5 \times 2 = 5 \times 4 = 5 \times 6 = 5 \times 8 = 0$ modulo 10) and thus not catch some single-digit errors. Using different weights on neighboring numbers means that most transpositions change the check digit; however, because all weights differ by an even number, this does not catch transpositions of two digits that differ by 5 (0 and 5, 1 and 6, 2 and 7, 3 and 8, 4 and 9), since the 2 and 5 multiply to yield 10. The ISBN-10 code instead uses modulo 11, which is prime, and all the number positions have different weights: 1, 2, ..., 10. This system thus detects all single-digit substitution and transposition errors (including jump transpositions), but at the cost of the check digit possibly being 10, represented by 'X'. (An alternative is simply to avoid using the serial numbers which result in an 'X' check digit.) ISBN-13 instead uses the GS1 algorithm used in EAN numbers. More complicated algorithms include the Luhn algorithm (1954), which captures 98% of single-digit transposition errors (it does not detect 90 → 09) and the still more sophisticated Verhoeff algorithm (1969), which catches all single-digit substitutions and transposition errors, and many (but not all) more complex errors. Similar is another abstract algebra-based method, the Damm algorithm (2004), that too detects all single-digit errors and all adjacent transposition errors. These three methods use a single check digit and will therefore fail to capture around 10% [citation needed] of more complex errors. To reduce this failure rate, it is necessary to use more than one check digit (for example, the modulo 97 check digit referred to below, which uses two check digits—for the algorithm, see International Bank Account Number). The final digit of a Universal Product Code, International Article Number, Global Location Number or Global Trade Item Number is a check digit computed as follows:[3][4] Adds the digits (up to but not including the check digit) in the even-numbered positions (second, fourth, sixth, etc.) to the result. Take the remainder of the result divided by 10 (i.e. the modulo 10 operation). If the remainder is equal to 0 then use 0 as the check digit, and if not 0 subtract the remainder from 10 to derive the check digit. A GS1 check digit calculator and detailed documentation is online at GS1's website.[5] Another official calculator page shows that the mechanism for GTIN-13 is the same for Global Location Number/GLN.[6] For instance, the UPC-A barcode for a box of tissues is "036000241457". The last digit is the check digit "7", and if the other numbers are correct then the check digit calculation must produce 7. Add the odd number digits: $0+6+0+2+1+5=14$. 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