Application for calculating precision grades and tolerances (**ISO 2768**)

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1. Introduction

This project proposes the development of a software application that automates the process of identifying the fundamental tolerance grade. Unlike the classical approach, where the grade is known first and the deviations are then determined, this application works in reverse: the user enters the limit deviations (upper and lower), and the algorithm calculates the tolerance zone and compares it with the standardized database (Table 1.0) to return the correct precision grade (for example: IT7, IT8, etc.).

2.1. Identification of Data

Input Data:

- **Nominal Dimension (N):** The base value of the dimension (in mm), limited to the interval [20, 50] according to the assignment. The nominal dimension, symbol **Dnom** for holes and **dnom** for shafts, is "the base dimension against which the upper and lower deviations are applied to define the limit dimensions."
- **Hole —** a term used to describe an internal feature or surface of a part.
- **Shaft —** a term used to describe an external feature or surface of a part.

- **The upper deviation** of a product characteristic represents the difference between its maximum permissible value and its nominal or reference value. For numerical characteristics, this deviation is calculated as $ASC = C_{max} - C_{nom}$.

- **Lower Deviation (Ei):** The lower deviation of a characteristic (AiC) represents the difference between its minimum permissible value and its nominal or reference value. For numerical characteristics:

$$AiC = Cmin - Cnom$$

Output Data:

- **Calculated Tolerance (T):** The tolerance defines the maximum permissible variation from the nominal value of a characteristic. For numerical characteristics, it is expressed as:

$$TC = Cmax - Cmin$$

- **Identified Precision Grade:** The precision of a characteristic expresses the degree of agreement between the actual characteristic and its nominal/reference value, determined by its tolerance and/or deviations.
- **Final result of the search** (e.g., “IT7”). If the value does not exist in the standard, the application displays **“UNKNOWN”**.

2.2. Mathematical Model

The logic of the application is based on calculating the width of the tolerance zone and comparing it with the discrete values in the table.

Calculation of the actual tolerance:

$T = Es - Ei$

Unit Normalization: Since the table stores mixed units (some in micrometers, others in millimeters), the algorithm converts everything to a common unit (millimeters) before comparison:

- For grades **IT01...IT11**: the table value is given in micrometers and must be divided by 1000.
- For grades **IT12...IT18**: the table value is given directly in millimeters.

3. Short description of the programming language used

For the development of this project, I chose the **Python** programming language. I selected Python because it is a modern language, very easy to read and understand, making it ideal for quick engineering calculations. Its syntax is simple (similar to English), which allowed me to focus on the logic of tolerances rather than on writing complex code.

To create the graphical interface (windows, buttons, input fields), I used the **Tkinter** library. A major advantage is that Tkinter comes integrated in the standard Python distribution, meaning no additional packages had to be installed. It is a simple library, yet powerful enough to build an intuitive and easy-to-use interface, exactly what was needed for this project.

4. Description and presentation of the developed program

The program is a Python application with a graphical interface built using Tkinter, which calculates the actual tolerance based on the entered deviations and identifies the corresponding IT grade from Table 1.0. The code retrieves the values entered by the user, checks whether the nominal dimension is within the 20–50 mm range, calculates the tolerance, and compares it with the standardized values. If a match is found, the application displays the IT grade; if not, it indicates that the tolerance is not standardized.

The interface includes input fields, a calculation button, and labels for displaying the results.

5. Usage steps

a) Nominal dimension (N)

- Enter the nominal dimension value in mm in the first field.
- Accepted range: **20–50 mm**. If the value is outside this range, the application will display an error.

b) Upper deviation (Es)

- Enter the upper deviation in mm (examples: 0.025, -0.010).

c) Lower deviation (Ei)

- Enter the lower deviation in mm (examples: 0, -0.035).
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d) Press the “IDENTIFY GRADE” button

e) Displaying the result

If the tolerance corresponds to a standard grade:

- In the “Identified Precision Grade” area, the grade appears (e.g., IT7) in green text.
- Below the result, an explanatory message appears: “The calculated value (…) corresponds to the ITx standard.”

If the tolerance does NOT exist in the table:

- The text **“UNKNOWN”** appears in red.
- The informational message becomes: “The calculated tolerance is not found in Table 1.0.”

Table 1.0.

Valori numerice ale treptelor de toleranțe fundamentale IT pentru dimensiuni nominale până la 3150 mm

Dimensiuni nom în mm		Trepte de toleranțe fundamentale																	
		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
peste	până la inclus.	Toleranțe µm											Toleranțe mm						
-	**3**	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,6	1	1,4
3	**6**	1	1,5	2,5	4	5	8	12	18	30	48	75	0,12	0,18	0,3	0,48	0,75	1,2	1,8
6	**10**	1	1,5	2,5	4	6	9	15	22	36	58	90	0,15	0,22	0,36	0,58	0,9	1,5	2,2
10	**18**	1,2	2	3	5	8	11	18	27	43	70	110	0,18	0,27	0,43	0,7	1,1	1,8	2,7
18	**30**	1,5	2,5	4	6	9	13	21	33	52	84	130	0,21	0,33	0,52	0,84	1,3	2,1	3,3
30	**50**	1,5	2,5	4	7	11	16	25	39	62	100	160	0,25	0,39	0,62	1	1,6	2,5	3,9
50	**80**	2	3	5	8	13	19	30	46	74	120	190	0,3	0,46	0,74	1,2	1,9	3	4,6
80	**120**	2,5	4	6	10	15	22	35	54	87	140	220	0,35	0,54	0,87	1,4	2,2	3,5	5,4
120	**180**	3,5	5	8	12	18	25	40	63	100	160	250	0,4	0,63	1	1,6	2,5	4	6,3
180	**250**	4,5	7	10	14	20	29	46	72	115	185	290	0,46	0,72	1,15	1,85	2,9	4,6	7,2
250	**315**	6	8	12	16	23	32	52	81	130	210	320	0,52	0,81	1,3	2,1	3,2	5,2	8,1
315	**400**	7	9	13	18	25	36	57	89	140	230	360	0,57	0,89	1,4	2,3	3,6	5,7	8,9
400	**500**	8	10	15	20	27	40	63	97	155	250	400	0,63	0,97	1,55	2,5	4	6,3	9,7
500	**630**	9	11	16	22	32	44	70	110	175	280	440	0,7	1,1	1,75	2,8	4,4	7	11
630	**800**	10	13	18	25	36	50	80	125	200	320	500	0,8	1,25	2	3,2	5	8	12,5
800	**1000**	11	15	21	28	40	56	90	140	230	360	560	0,9	1,4	2,3	3,6	5,6	9	14
1000	**1250**	13	18	24	33	47	66	105	165	260	420	660	1,05	1,65	2,6	4,2	6,6	10,5	16,5
1250	**1600**	15	21	29	39	55	78	125	195	310	500	780	1,25	1,95	3,1	5	7,8	12,5	19,5
1600	**2000**	18	25	35	46	65	92	150	230	370	600	920	1,5	2,3	3,7	6	9,2	15	23
2000	**2500**	22	30	41	55	78	110	175	280	440	700	1100	1,75	2,8	4,4	7	11	17,5	28
2500	**3150**	26	36	50	68	96	135	210	330	540	860	1350	2,1	3,3	5,4	8,6	13,5	21	33

Formule pentru toleranțe fundamentale pentru treptele IT1 până la IT18

Dimensiune nomin.[mm]		Trepte de toleranțe fundamentale																	
		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
peste	până la	**Formule pentru toleranțe fundamentale (Rezultate în µm)**																	
-	**500**	-	-	-	-	7i	10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i	1600i	2500i
500	**3150**	2I	2,7I	3,7I	5I	7I	10I	16I	25I	40I	64I	100I	160I	250I	400I	640I	1000I	1600I	2500I

6. Bibliography

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