Challenge 1: Gen AI & Brake Pad Recipe Creation

1. Data Dictionary

The dataset contains 337 compound recipes identified by a *compound_id,* used to produce braking pads. For each compound, a performance test was conducted to evaluate the friction coefficient μ (mu) of the pads in predefined conditions. The performance test consists of 18 sections and 124 braking events, during which μ and other physical properties are measured 31 times for each braking event. For each compound (or recipe) we report the values of these variables sampled at 3844-time instants.

Column Name	Description	Data Type
time_index	incremental value for each compound characterizing the order of the test. For each compound_id there are 3844 points corresponding to consecutive time steps across all the test brakings	int
compound_id	compound identifier	str
braking_id	braking event identifier, constructed by concatenating the step and stop id	int
step	label of the section within the test. For details see 'Performance Test Specification'	str
time	progressive time [s] per braking_id	float
pressure_bar	pressure [bar] during performance test	float
temp_disc_c	disc temperature [°C]	float
speed_kph	speed [km/h] during performance test	float
mu	friction coefficient	float
A_* B_* C_* D_* E_* F_*	percentage raw material ingredients within the compound. The raw materials belong to one of five material classes encoded with the letters A, B, C, D, E or F. The composition is uniquely associated to the compound_id	float

2. Compound composition constraints

The cumulative percentage of the materials in the different classes must stay withing a certain range. The theoretical constraints are detailed in the following table:

Material class code	min %	max %
A	0	12
B	1	30
C	0	18
D	0.4	1
E	45	92
F	3	27

So, for instance, the cumulative percentage of all materials in class A cannot exceed 12%.

3. Physical formulas

Friction Coefficient (μ):

The friction coefficient (μ) represents the coefficient of friction between the brake pads and the disc rotor. It quantifies how effectively the brake pads can grip and slow down the rotor. The relationship between the frictional force ($F_{friction}$), normal force (N), and the friction coefficient (μ) is given by:

$$F_{friction} = \mu * N$$

Pressure (P):

The brake system's hydraulic pressure (P) is applied to the brake caliper, which in turn pushes the brake pads against the disc rotor. In Physics the pressure is a measure of force (F) over a specific area (A). In a braking system, the force is the friction force, and the area is the area of the caliper piston (A_{piston}) The formula for pressure is:

$$P = \frac{F_{friction}}{A_{piston}}$$

Torque (τ):

The torque generated in a disc braking system is the result of the frictional force acting on the disc rotor. It depends on the Frictional force and the radius of brake disc (r). The formula for torque is:

$$\tau = F_{friction} * r$$

4. Performance target

The rating for each compound is based on the average friction coefficient μ (mu) across all test braking events. The target value is 0.6, the accepted tolerance is ± 0.1.

5. Test specification

Step	No. of brake applications	Torque [kg·m]	Deceleration [m/s²]	Initial T [°C]	Initial speed [km/h]	Final speed [km/h]
Burnishing 1	10	23.8	4	100	80	30
	7	23.8	4	200	80	30
Characteristic values 1	3	23.8	4	100	112	0
Burnishing 2	5	23.8	4	200	196	30
Characteristic values 2	3	23.8	4	100	112	0
Deceleration series 1 Vint ≈ 28 % of Vmax	1	11.9	2	100	79.2	0
	1	23.8	4	100	79.2	0
	1	35.6	6	100	79.2	0
	1	47.5	8	100	79.2	0
	1	59.4	10	100	79.2	0
Deceleration series 2 Vint = 40 % of Vmax	1	11.9	2	100	112	0
	1	23.8	4	100	112	0
	1	35.6	6	100	112	0
	1	47.5	8	100	112	0
	1	59.4	10	100	112	0
Deceleration series 3 Vint ≈ 57 % of Vmax	1	11.9	2	100	158.4	0
	1	23.8	4	100	158.4	0
	1	35.6	6	100	158.4	0
	1	47.5	8	100	158.4	0
	1	59.4	10	100	158.4	0
Deceleration series 4 Vint = 80 % of Vmax	1	11.9	2	100	224	0
	1	23.8	4	100	224	0
	1	35.6	6	100	224	0
	1	47.5	8	100	224	0
	1	59.4	10	100	224	0
Characteristic values 3	3	23.8	4	100	112	0
Fading 1	20	23.8	4	40	100	0
Characteristic values 4	3	23.8	4	100	112	0
Fading 2	20	23.8	4	40	100	0
Characteristic values 5	3	23.8	4	100	112	0
Increasing temperature	1	23.8	4	50	112	0
	1	23.8	4	100	112	0
	1	23.8	4	150	112	0
	1	23.8	4	200	112	0
	1	23.8	4	250	112	0
	1	23.8	4	300	112	0
	1	23.8	4	350	112	0
	1	23.8	4	400	112	0
Deceleration series 5 (Tint = 400 °C)	1	23.8	2	400	112	0
	1	23.8	4	400	112	0
	1	23.8	6	400	112	0
	1	23.8	8	400	112	0
	1	23.8	10	400	112	0
Decreasing temperature	1	23.8	4	400	112	0
	1	23.8	4	350	112	0
	1	23.8	4	300	112	0
	1	23.8	4	250	112	0
	1	23.8	4	200	112	0
	1	23.8	4	150	112	0
	1	23.8	4	100	112	0
	1	23.8	4	50	112	0
Characteristic values 6	3	23.8	4	100	112	0
Characteristic values 7	3	23.8	4	100	112	0

*inertia [$kg\ m^2$] is constant and equal to 17.7

6. Required submission output

Submissions files must be .csv files with the same format as the input data (see Data Dictionary). More specifically:

- Generate 10 to 30 new candidate compounds;
- Compounds must be uniquely identified by a *compound id* which can be an alpha-numeric string of your choice with maximum 10 characters;
- The composition of compounds in terms of percentages of raw materials must be provided for *each* row of the .csv file;
- For each compound, we expect 31 time points for each of the 124 test brakings in the defined test for a total of 3844 rows.
  Each row corresponds to a time instant, identified by a step, braking_id, and time index. You must report a value of time (in s), pressure (in bar), temperature (in °C), speed (in kph) and mu.
- The file name should be *submission_<n>.csv* where <n> is the checkpoint number. e.g. for checkpoint 1 , file name should be *submission_1.csv*