LLM-Compatible Rubric for Predicting Math Problem Difficulty and Grade Level (Grades 1–12)

---

1. Purpose

This rubric provides a structured framework for a Large Language Model (LLM) to analyze a **summary** of a math problem and predict both its difficulty level **and corresponding grade level**. The rubric guides feature extraction from the prompt itself and uses quantifiable criteria to assess complexity aligned with educational standards.

---

2. Difficulty Levels

- **Level 1: Novice**
- **Level 2: Beginner**
- **Level 3: Intermediate**
- **Level 4: Advanced**
- **Level 5: Expert**

Each difficulty level also corresponds to a predicted grade range:

Difficulty Level	Typical Grade Band
Level 1: Novice	Grades 1–4
Level 2: Beginner	Grades 5–7
Level 3: Intermediate	Grades 8–10
Level 4: Advanced	Grades 11–12
Level 5: Expert	Advanced Grade 12 / Competition / University Prep

---

3. Assessment Criteria

Each problem is summarized and evaluated based on the following extracted features:

Criterion	Description	Extraction Clues	Rating Scale
Grade Alignment	Maps to official curriculum expectations	Keywords, topic, notation, standard tags	G1 to G12
Conceptual Complexity	Number and abstraction level of core concepts	Presence of abstract terms (e.g., "limits", "proof")	1 (simple) to 5 (abstract/ multiple)

Criterion	Description	Extraction Clues	Rating Scale
Procedural Complexity	Number of steps/ operations required	Verb chains, operation complexity, compound expressions	1 to 5
Required Prior Knowledge	Pre-requisite concepts or formulas needed	Reference to rules, theorems, or implied knowledge	1 to 5
Problem Structure			
- **Directness** (explicit vs. hidden question)			
- **Step Count** (single vs. multi-step)			
- **Familiarity** (standard vs. novel problem type)			
- **Contextual Complexity** (abstract vs. real-world)			
- **Quantity Management** (1 variable vs. multiple interrelated values)			
- **Solution Path** (unique vs. multiple)			
- **Distractors** (trick elements or ambiguity)	Type of phrasing, number of clues, novelty of logic	Each sub-dimension scored 1–5; subtotaled max = 35	
Reasoning Type	Logical, spatial, quantitative, abstract, inductive	Problem tag or reasoning verbs (e.g., “prove”, “visualize”)	1 to 5
Time to Solve	Expected solving duration	Typical for domain/ complexity	<1 min to >20 min

4. Domains Covered

- Arithmetic (Grades 1–6)
- Algebra (Grades 6–12)
- Geometry (Grades 3–12)
- Trigonometry (Grades 9–12)
- Pre-Calculus (Grades 10–12)
- Calculus (Grades 11–12)

- Statistics & Probability (Grades 6–12)
- Discrete Math (Grades 9–12)
- Number Theory (Grades 7–12)
- Problem-Solving Strategies (Grades 1–12)

---

5. Scoring Example: Summarized Algebra Problem (Grade 8)

Prompt Summary: "A student solves a quadratic equation by isolating a term, taking the square root, and simplifying."

Criterion	Score
Grade Alignment	G8
Conceptual Complexity	3 (quadratic equation, square root)
Procedural Complexity	3 (isolate, square root, solve)
Required Prior Knowledge	3 (inverse ops, squaring, isolating variable)
Problem Structure Subscore	
- Direct: 1	
- Multi-step: 3	
- Known Type: 2	
- Contextual Complexity: 1	
- Number of Variables: 2	
- Unique Path: 3	
- Some Distractors: 2	14
Reasoning Type	Quantitative (2)
Time Estimate	3–5 minutes
Predicted Difficulty Level	**3 – Intermediate**
Predicted Grade Level	**Grade 8–9**

---

6. Sample Summarized Prompts and Predictions

A. Geometry (Grade 7)

Summary: "Calculate the area of a triangle given its base and height." **Difficulty:** Level 1 – Novice
Grade Level: Grade 6–7

B. Trigonometry (Grade 11)

Summary: "Solve $\sin(x) = \frac{\sqrt{2}}{2}$ for x in one period." **Difficulty:** Level 3 – Intermediate
Grade Level: Grade 10–11

C. Pre-Calculus (Grade 12)

Summary: "Find the domain of a rational function involving a square root in the denominator." **Difficulty:** Level 3 – Intermediate
Grade Level: Grade 11–12

D. Calculus (Grade 12)

Summary: "Differentiate a product of a polynomial and trigonometric function." **Difficulty:** Level 4 – Advanced
Grade Level: Grade 12

E. Discrete Math (Grade 11)

Summary: "Count distinct permutations of a word with repeating letters." **Difficulty:** Level 5 – Expert
Grade Level: Grade 12 / Competition Level

---

7. Application by LLM

For each new math problem summary: 1. Extract features from the problem summary using the defined criteria. 2. Score each criterion based on extracted evidence. 3. Aggregate scores to compute total difficulty. 4. Use the rubric table to map scores to: - Categorical difficulty level (1–5) - Predicted grade level (G1–12)

---

8. Summary Table: Difficulty and Grade Mapping

Total Score Range	Difficulty Level	Predicted Grade Range
8–14	Level 1: Novice	Grades 1–4
15–21	Level 2: Beginner	Grades 5–7
22–28	Level 3: Intermediate	Grades 8–10
29–35	Level 4: Advanced	Grades 11–12
36+	Level 5: Expert	Advanced Grade 12 / Competition

This document serves as a comprehensive reference for training and evaluating LLM performance in predicting both difficulty level and grade-level alignment of math problems using **summarized problem features** extracted directly from prompts.