DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 2.8: Gradient and Classification

GTU Course Instructor

Civil Engineering

July 23, 2026

Introduction to Gradients I

A gradient is the rate of rise or fall of the track with respect to the horizontal. It is expressed as a ratio of the vertical distance to the horizontal distance, or as a percentage.

Key Points

- Expressed as 1 in 'n' (1 unit vertical for every 'n' units horizontal)
- Also expressed as a percentage (e.g., 1%)
- Crucial for route alignment and locomotive hauling capacity

Purpose of Providing Gradients I

Gradients are introduced in railway tracks to accommodate natural topography, reduce earthwork, and reach specific elevations safely and economically.

Key Points

- To reach a station situated at a different elevation
- To follow the natural contours of the ground to minimize cut and fill
- To drain off rainwater, especially in station yards and cuttings

Types of Gradients I

Depending on their severity and location, gradients in railway engineering are classified into several distinct categories to govern train operations and track design.

Key Points

- Ruling Gradient
- Momentum Gradient
- Pusher or Helper Gradient
- Gradients in Station Yards

Standard Values (Indian Railways) I

Standard gradients specified for various terrains according to Indian Railways standards.

Key Points

- Terrain | Ruling Gradient | Station Yard Gradient
- Plain | 1 in 150 to 1 in 250 | 1 in 1000
- Hilly | 1 in 100 to 1 in 150 | 1 in 400

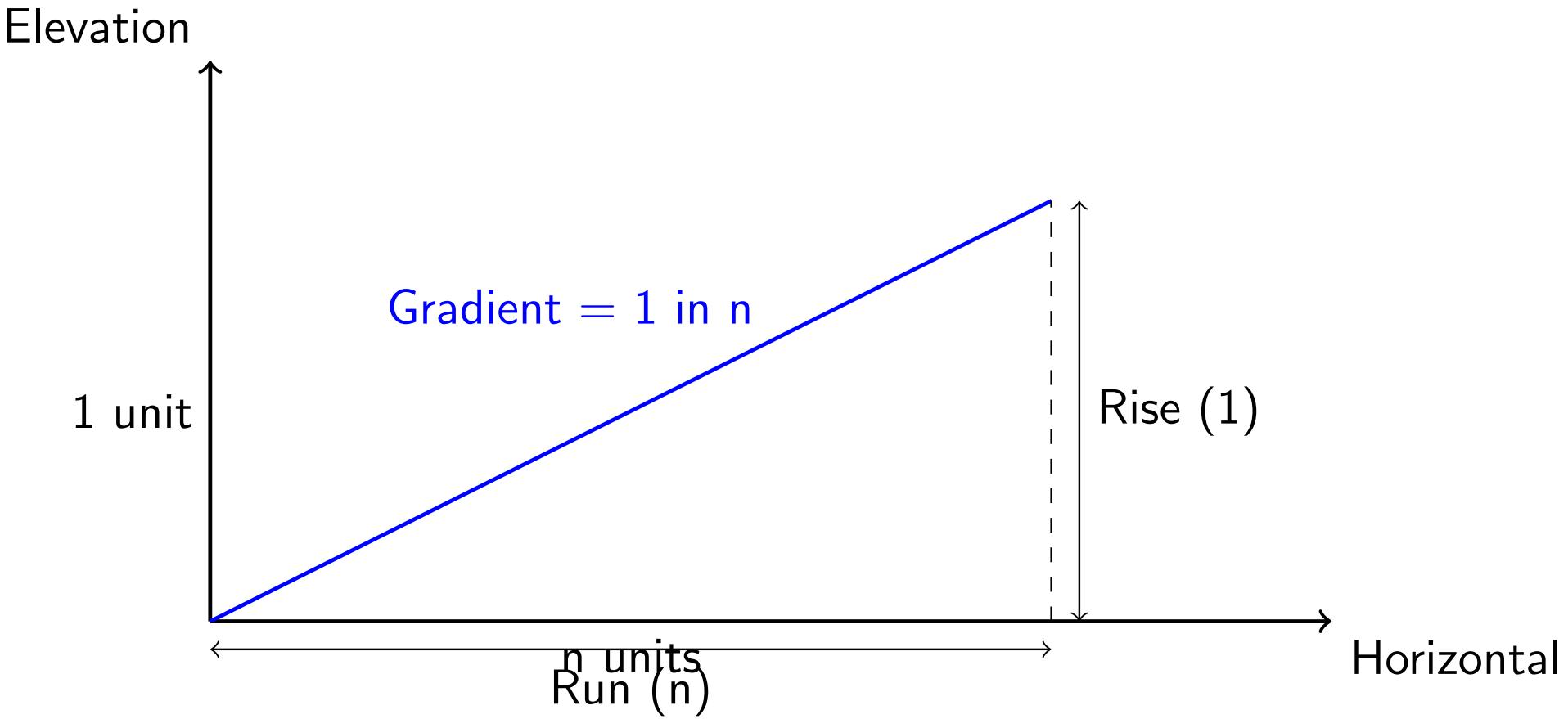
Ruling Gradient I

The ruling gradient is the maximum gradient allowed on a particular section of track. It determines the maximum load that a locomotive can haul on that section at the minimum required speed.

Key Points

- Dictates the maximum trailing load for a single locomotive
- Usually varies from 1 in 150 to 1 in 250 in plain terrain
- Extra power is required if the load exceeds the hauling capacity governed by the ruling gradient

Ruling Gradient Profile I



Momentum Gradient I

A momentum gradient is steeper than the ruling gradient but can be overcome by a train using the momentum gained while traveling down an adjoining falling gradient.

Key Points

- No speed restrictions should be present at the base of the gradient
- Allows for economical track alignment by avoiding deep cuttings
- Train speed decreases continuously but must remain above a critical limit

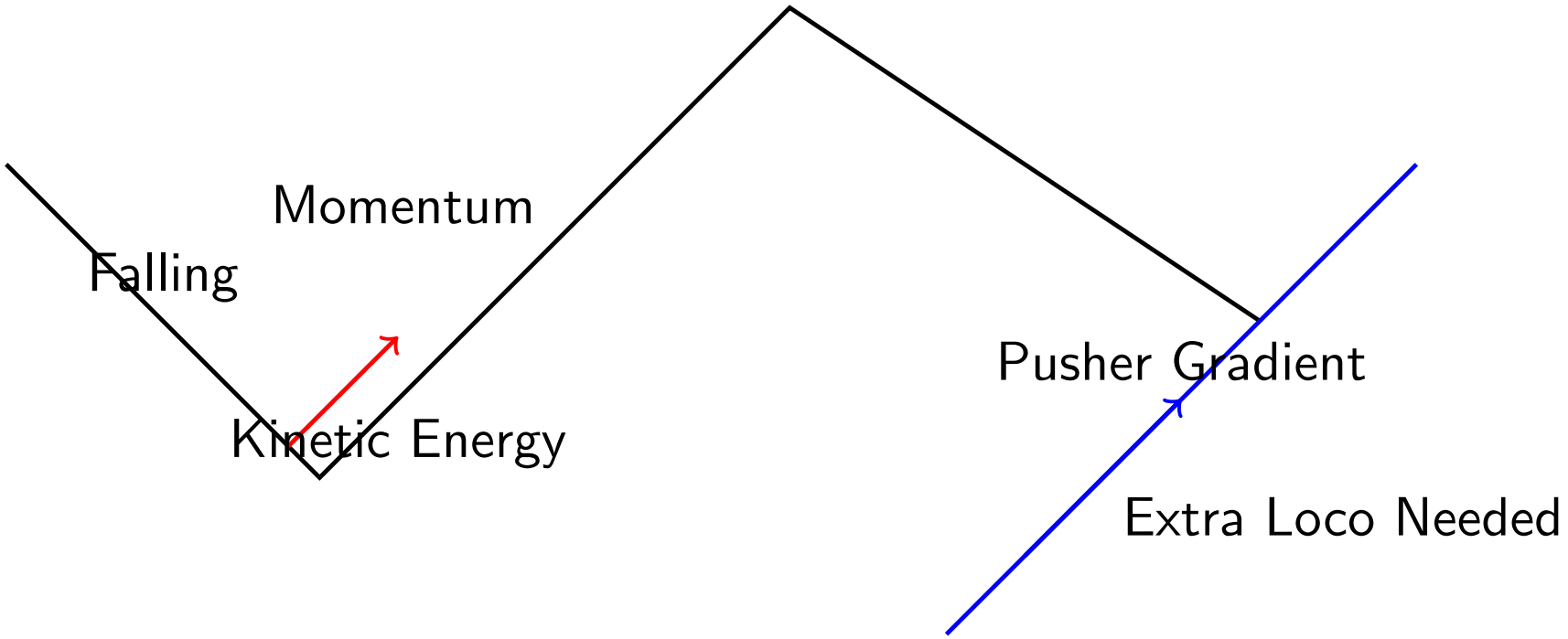
Pusher or Helper Gradient I

When a gradient is so steep that a single locomotive cannot haul the train, an extra engine (pusher) is attached. This gradient is called a pusher gradient.

Key Points

- Used in mountainous regions to avoid excessively long alignments
- Reduces the length of the track and travel time
- Commonly ranges from 1 in 37 to 1 in 50 on Indian Railways (e.g., Darjeeling Himalayan Railway)

Momentum vs Pusher Gradient I



Gradients in Station Yards I

Station yards require flat gradients primarily to prevent standing vehicles from rolling away due to wind or gravity, and to facilitate the easy starting of trains.

Key Points

- Maximum recommended gradient in station yards is 1 in 400, ideally 1 in 1000
- Ensures safety of uncoupled wagons
- Reduces tractive effort required to start a train from rest

Summary I

Gradients are essential for track alignment, classified by severity and operational needs. Understanding ruling, momentum, pusher, and station yard gradients ensures safe and efficient railway design.

Key Points

- Ruling gradient dictates hauling capacity
- Momentum gradient utilizes kinetic energy
- Pusher gradient requires auxiliary engines
- Station yards require very mild gradients for safety