Balancing, Falling & Making the Switch

The Essential Skills of Skiing

Ron LeMaster

Oslo, 2012

“Riding” Sports

- Skiing, alpine and tele
- Snowboarding
- Surfing
- Skateboarding
- Etc.

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What They Have in Common

- Balancing on a moving platform whose motion is always changing

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Mechanically Speaking…

- They're all *inverted pendulums*

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The Fundamental Skill of Riding

- Balancing on a moving platform, while that movement changes

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What is “Balance”?

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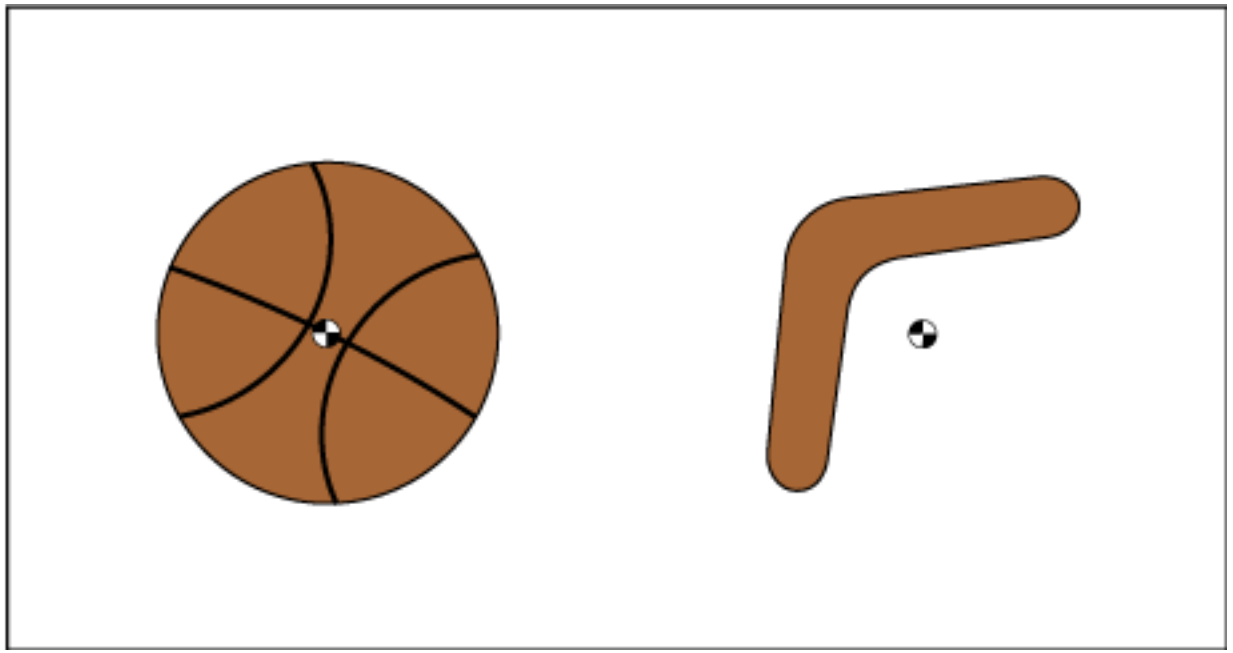
Center of Mass



- The same as center of gravity

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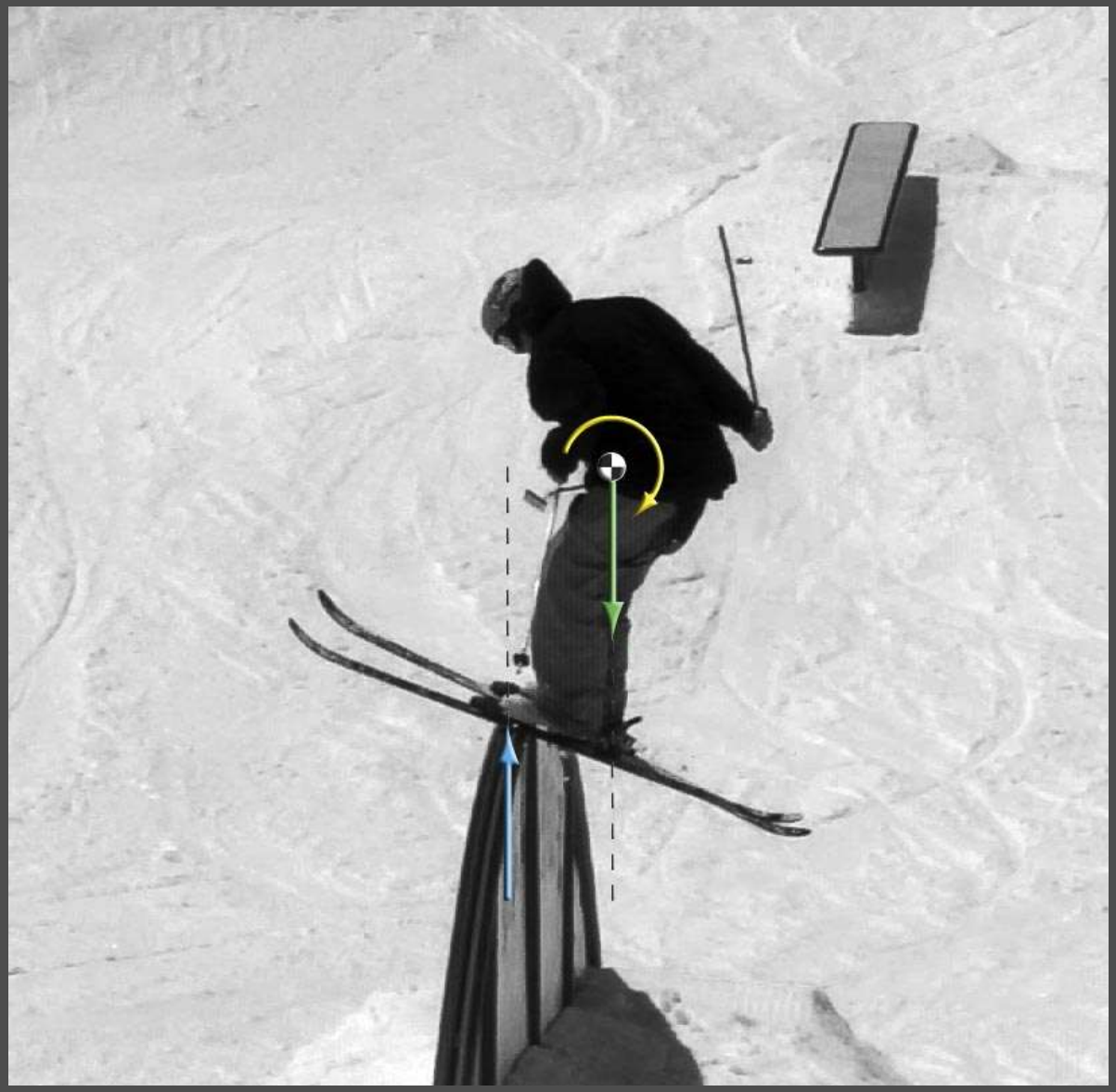

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What is Balance?

- "You don't fall over"
- The force of the snow pushing on you passes through your center of mass
- If it doesn't, you *topple*
  - *(Norwegian: velte)*

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The Balance Axis

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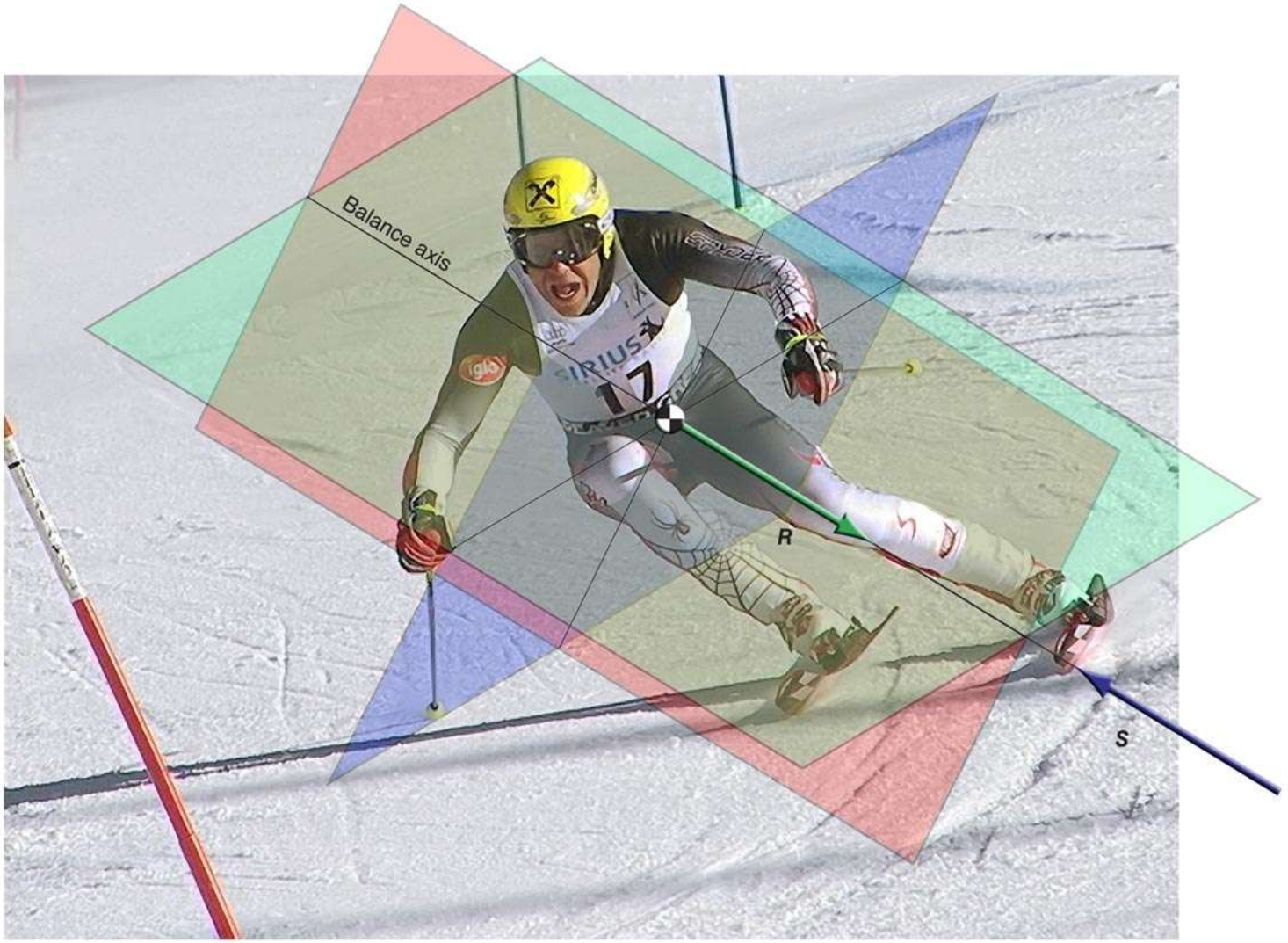

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Force and Pressure

- Closely related
- Pressure is force spread over a surface
- If the size of the surface is constant
  - High force = high pressure
  - Low force = low pressure
- People have a better intuitive sense of pressure than of force

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Fundamental Skill of Skiing

- Balancing on a moving platform, while that movement changes
- In skiing, the platform is the ski

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Fundamental Skill of Skiing

- Being tuned in to the force from the snow acting on you: it's size and its *direction*
- Arranging your body and skis so that force goes through your center of mass
- Anticipating how that force will change, especially it's *direction*

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- Knowing where the *balance axis* is, and anticipating how it will change

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Balancing in a Turn

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What Makes You Turn?

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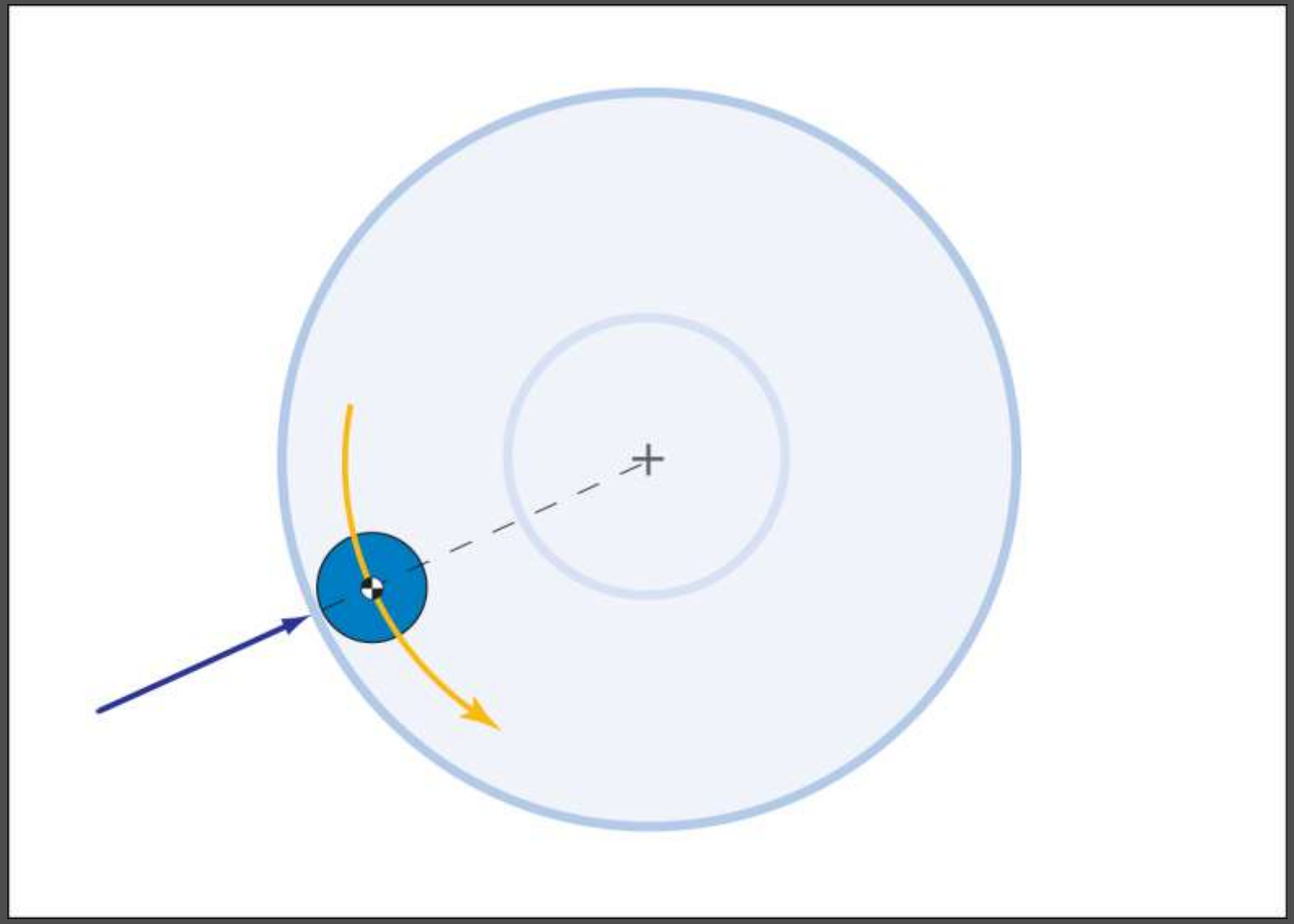

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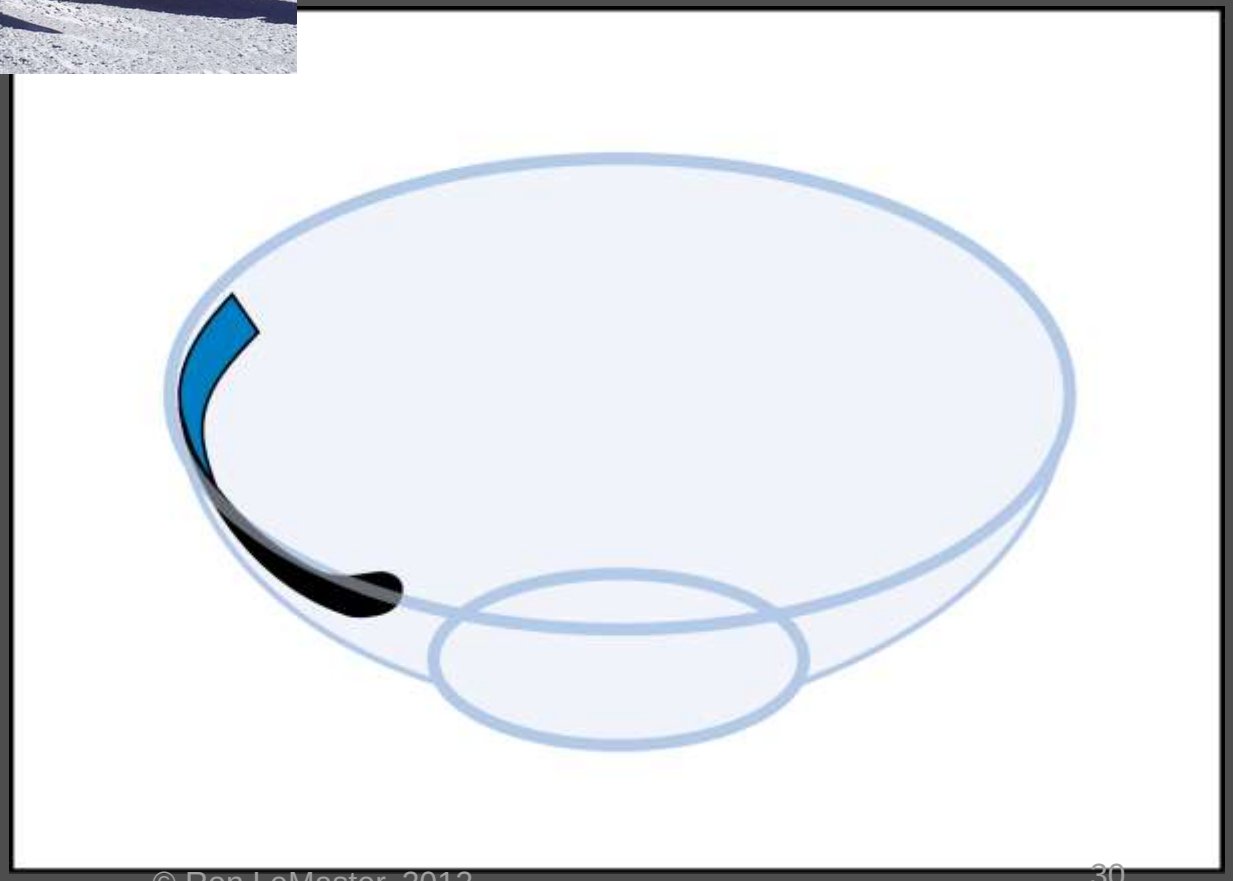

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Balancing in a Turn

- To balance against gravity and centrifugal force, the skier must be inclined into the turn
- Center of mass has to be closer to the center of the turn than the outside foot
- The sum of gravity and centrifugal force must pass through a point with the base of support

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Linking Turns

- The skier's CM and point of support must switch sides with each other

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Learning to Walk

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The Key Skill in Advanced Skiing

- Linking turns through deliberate toppling
- "Falling into the turn"

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Controlled Toppling

- Developing judgment is crucial
- Early turns use fast pivots
- As speeds and lateral forces increase, things get harder because you're moving between positions of greater inclination
- As hill gets steeper it gets harder because it's a longer time before you get some force

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The Estimation Problem

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The Estimation Problem

- Before you begin the transition, you must estimate
  - Where exactly it will end
  - How much lateral (centrifugal) force you will experience
  - How fast to topple

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How to Topple (Velte)

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Remove Support of the Downhill Foot

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Make the Feet Slow Down

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Make the Feet Turn More Sharply

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Make the Feet Turn More Sharply

- Angulation
- Tip pressure
- Reduced inclination
- Terrain
- Turning out of the fall line

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Make the Upper Body Go Straighter

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Make the Upper Body Go Straighter

- Disengage the upper body from the feet
- Relax knee and hip extensors
- Contract hip flexors

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Pole Plant

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Pole Plant

- Provides lateral support during transition
- Enables skier to commit sufficiently

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Summary

- Skiing involves balancing on a moving platform whose movement is changing
- Learning to ski is learning to deal with more complicated changes
- *The key is being sensitive to the force from the snow (pressure), and anticipating how it will change*

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- High-level skiing involves
  - Knowing when and how to go out of balance in a controlled way
  - Estimating the parameters of the transition well
  - Picking the best technique for the situation

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How Skis Carve

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What Makes a Ski Hold?

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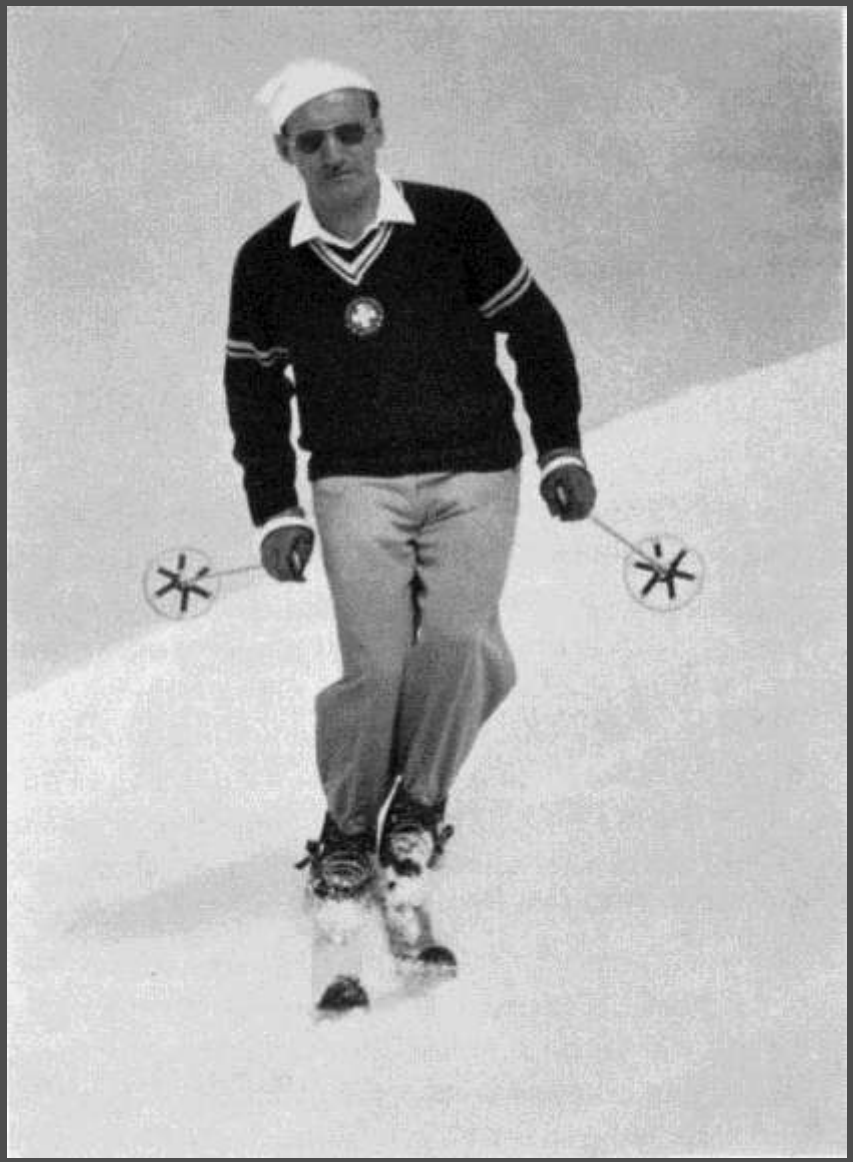

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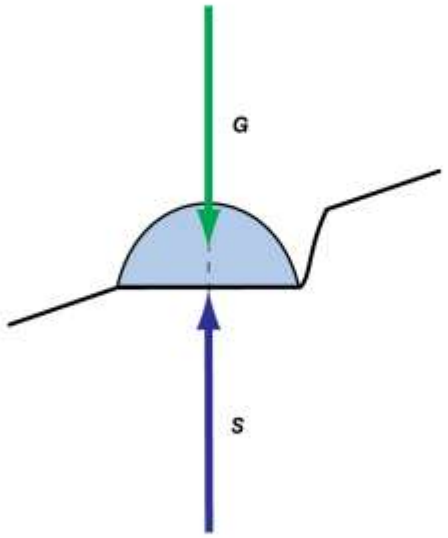
The Ski Cuts a Platform



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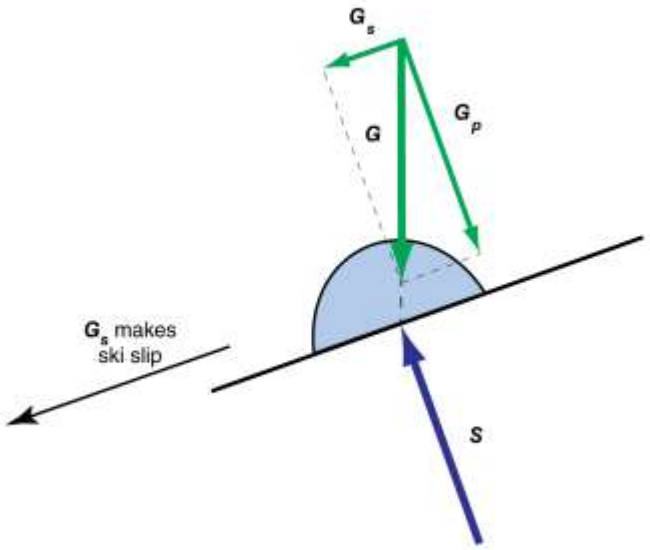

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Platform Angle

- The angle between the base of the ski (the platform), and the balance axis

- *Not* the same as the edge angle

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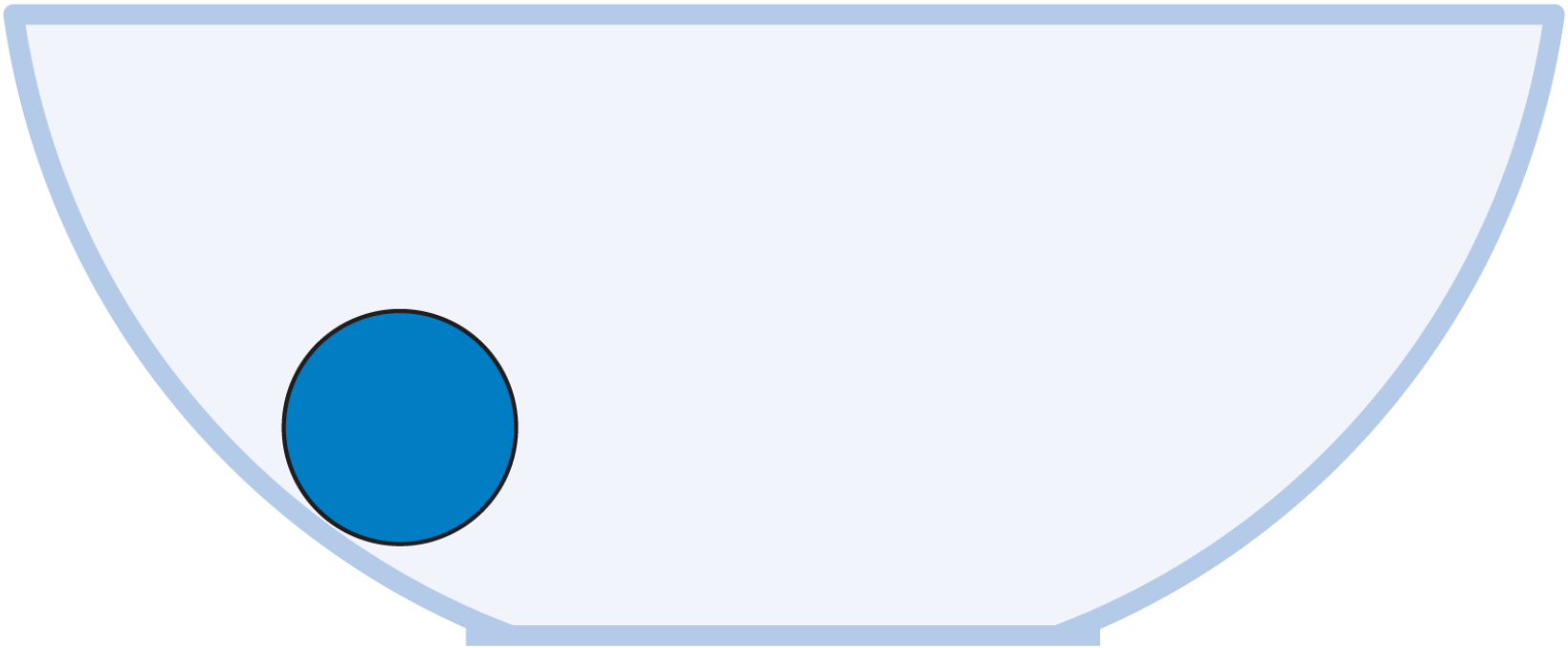

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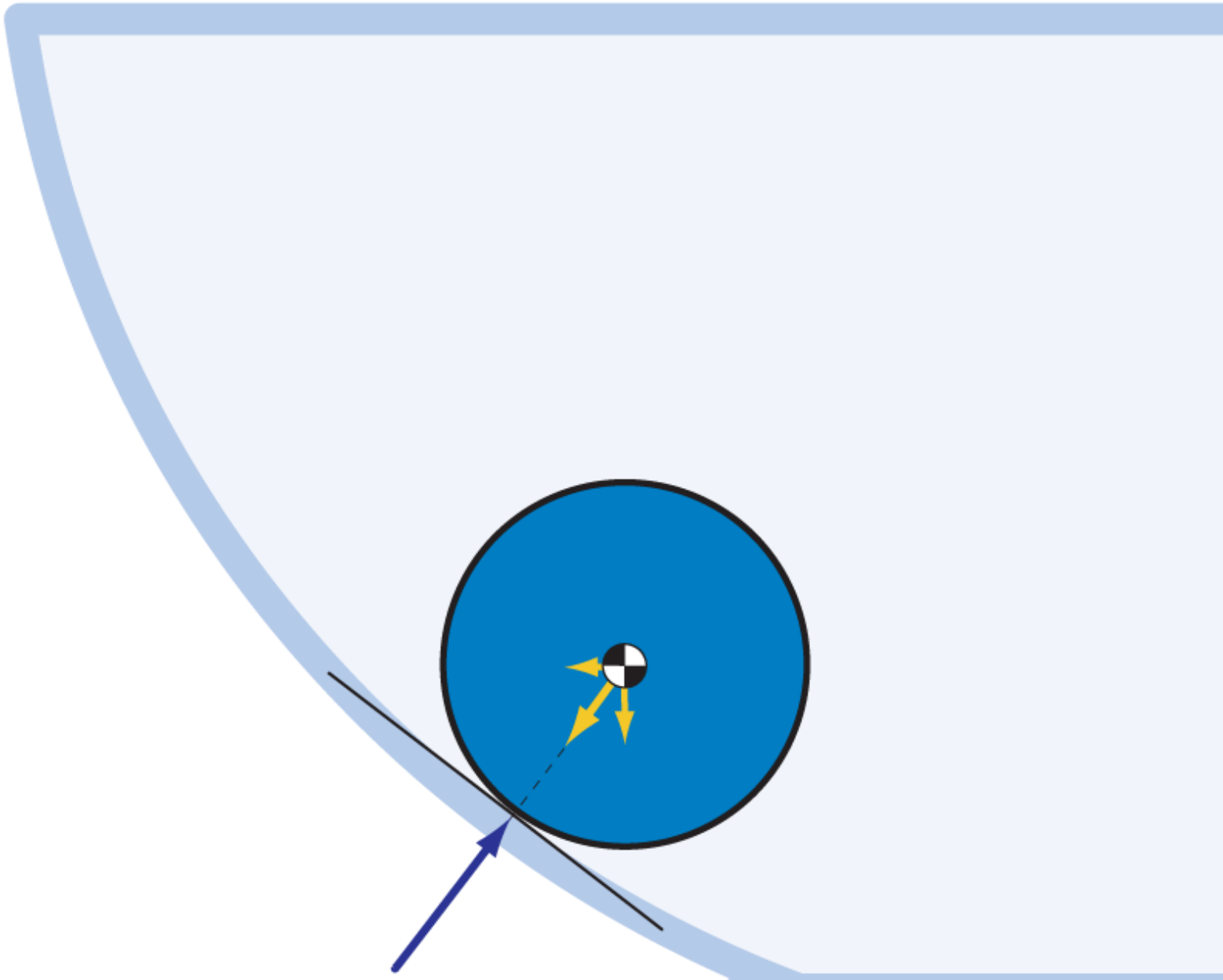

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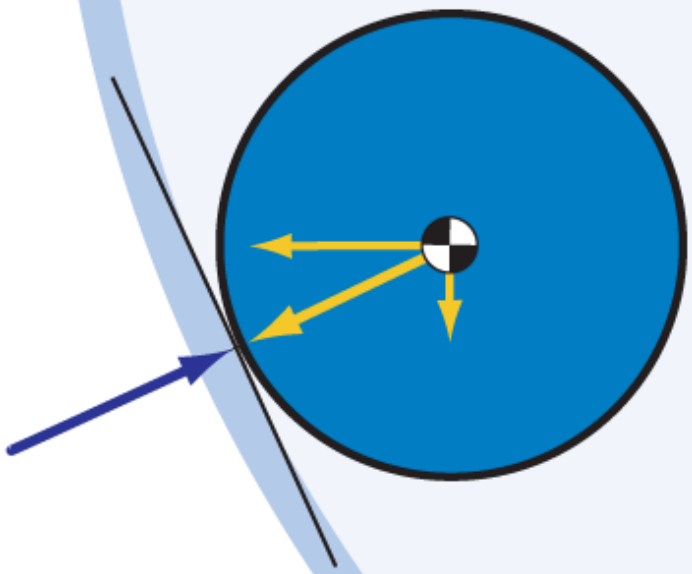

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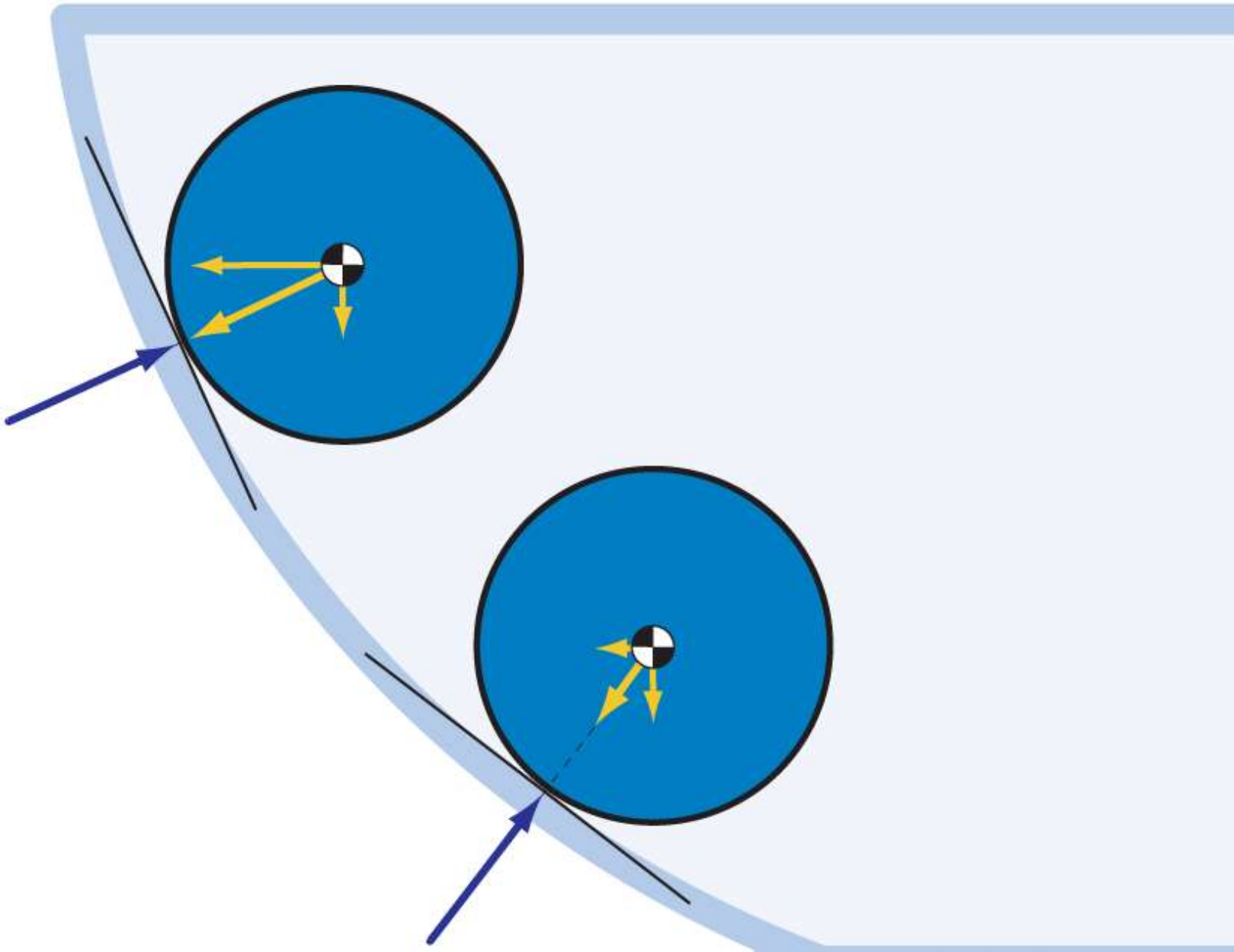

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Platform Angle

- Carving
  - <= 90 deg., ski holds
- Oversteering (skidding)
  - > 90 deg., ski slips

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Platform Angle

- The difference between carving and skidding

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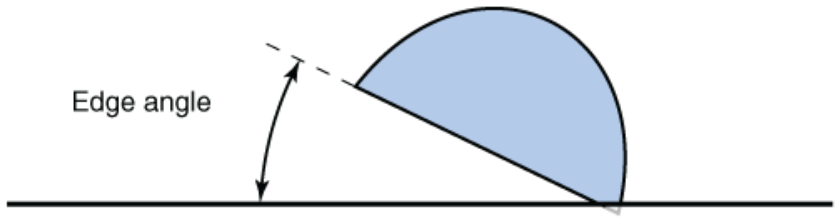
Edge Angle



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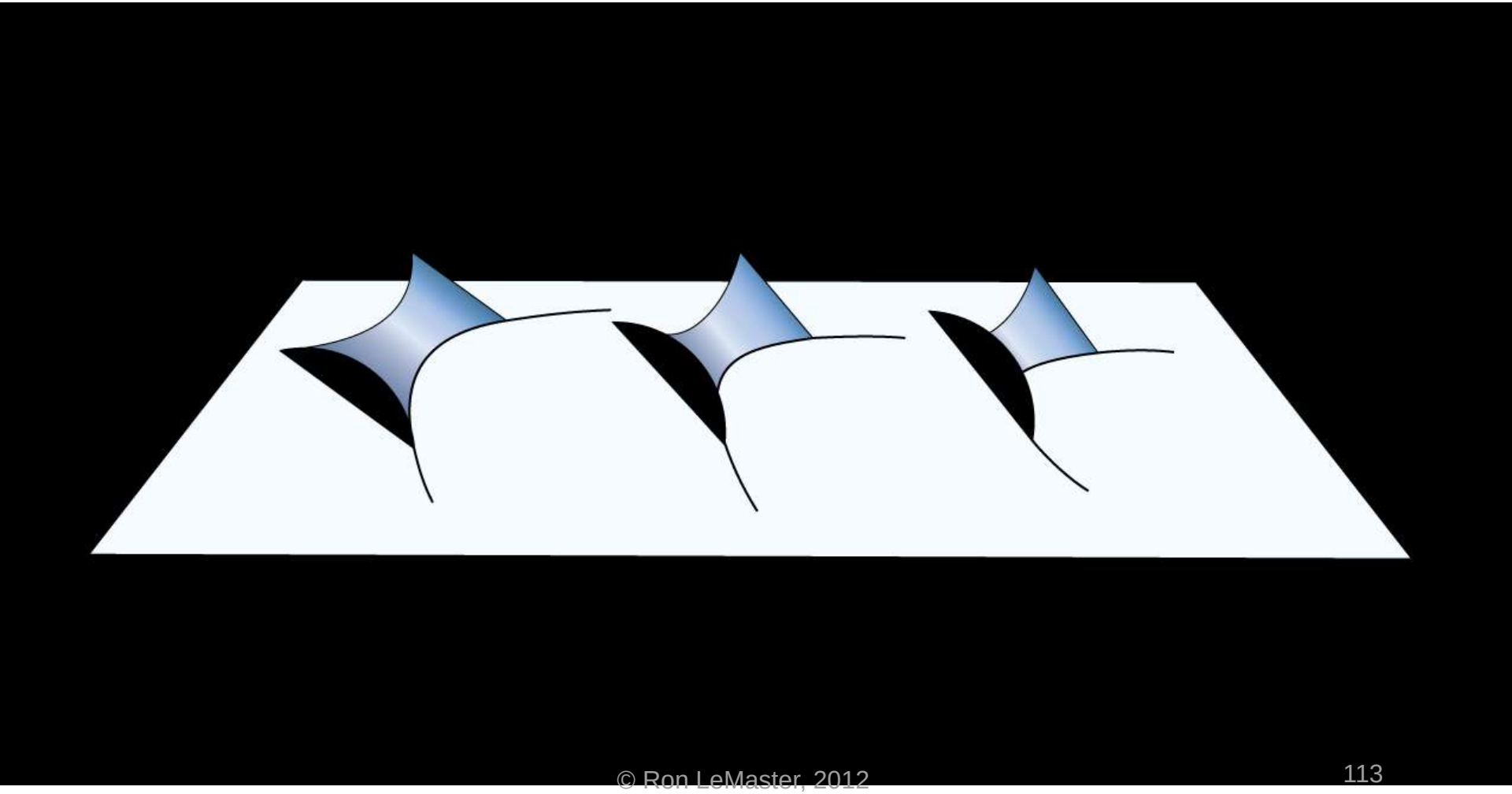
Reverse Camber on Hard Snow



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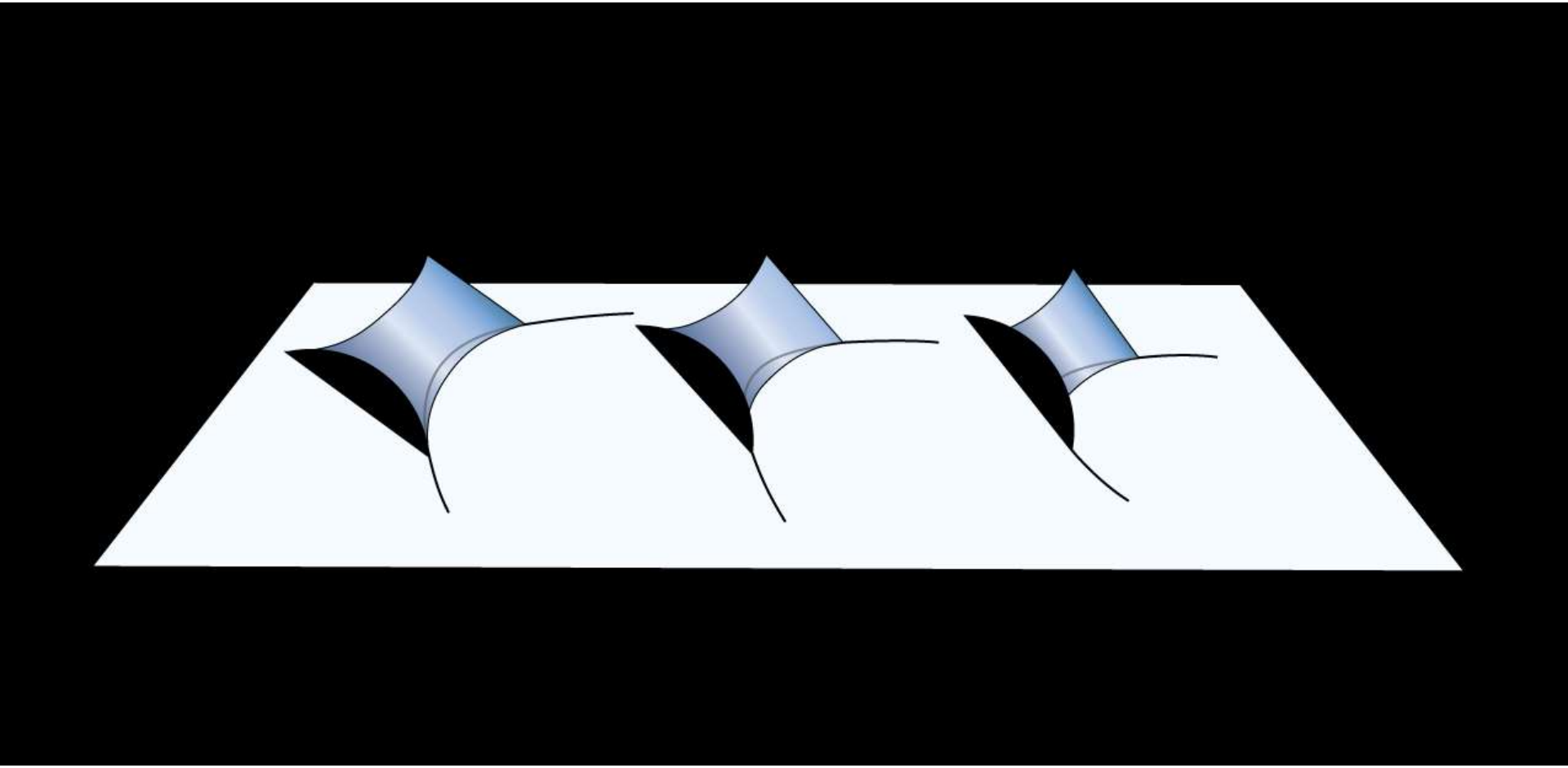
Reverse Camber on Soft Snow



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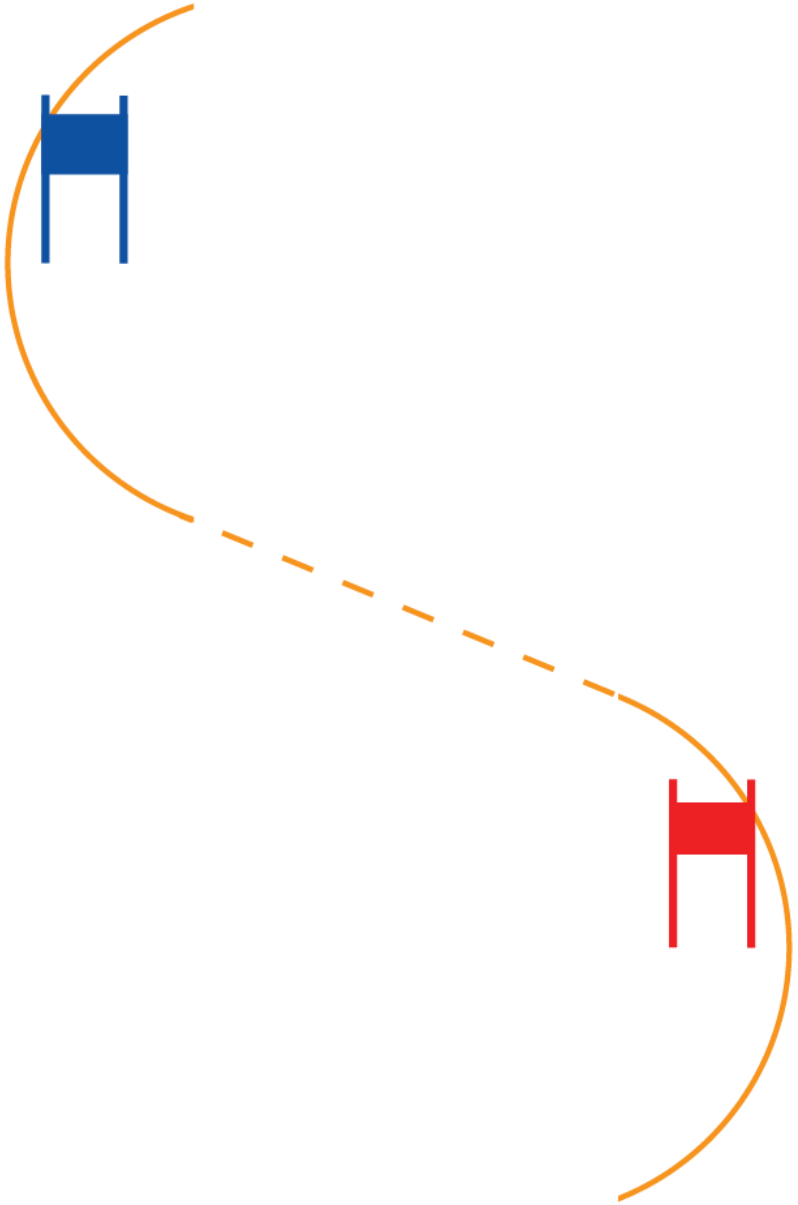

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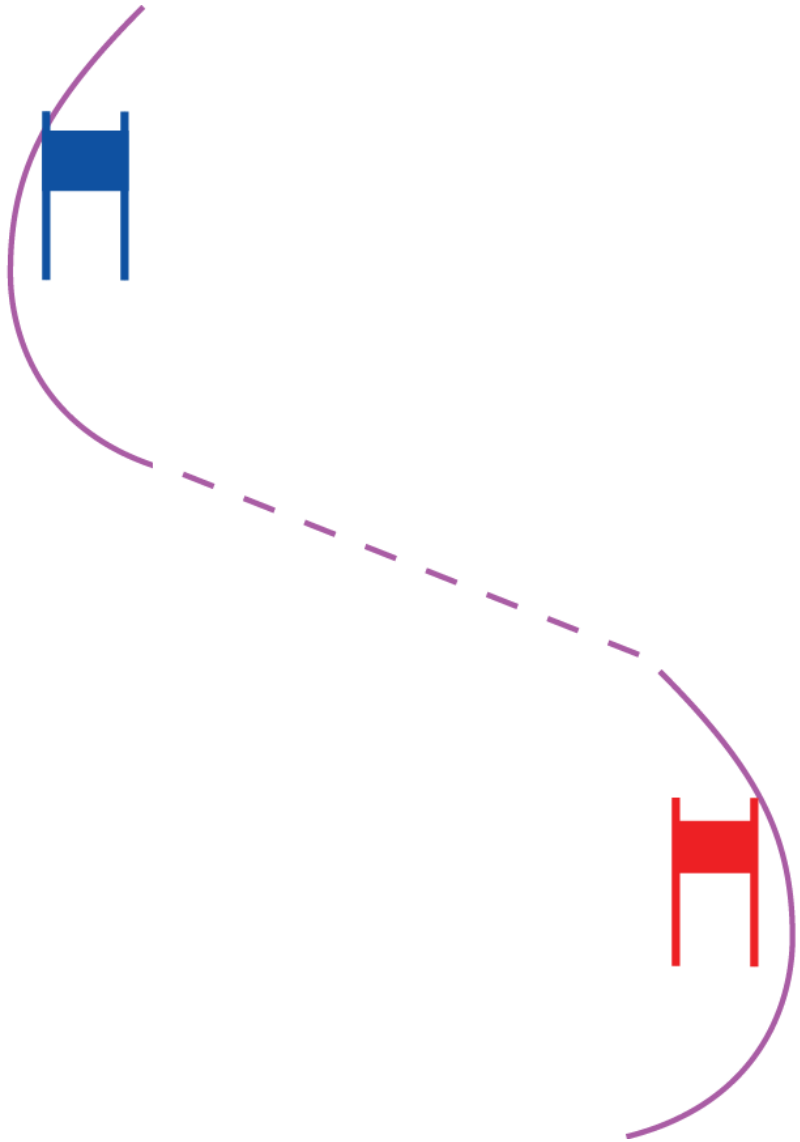

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- About 8 deg. difference in edge angle of outside ski
- Outside ski edge angle 65° vs 57° (~8°)
- Carving radius 15m vs 19m (35m sidecut radius on infinitely hard snow)

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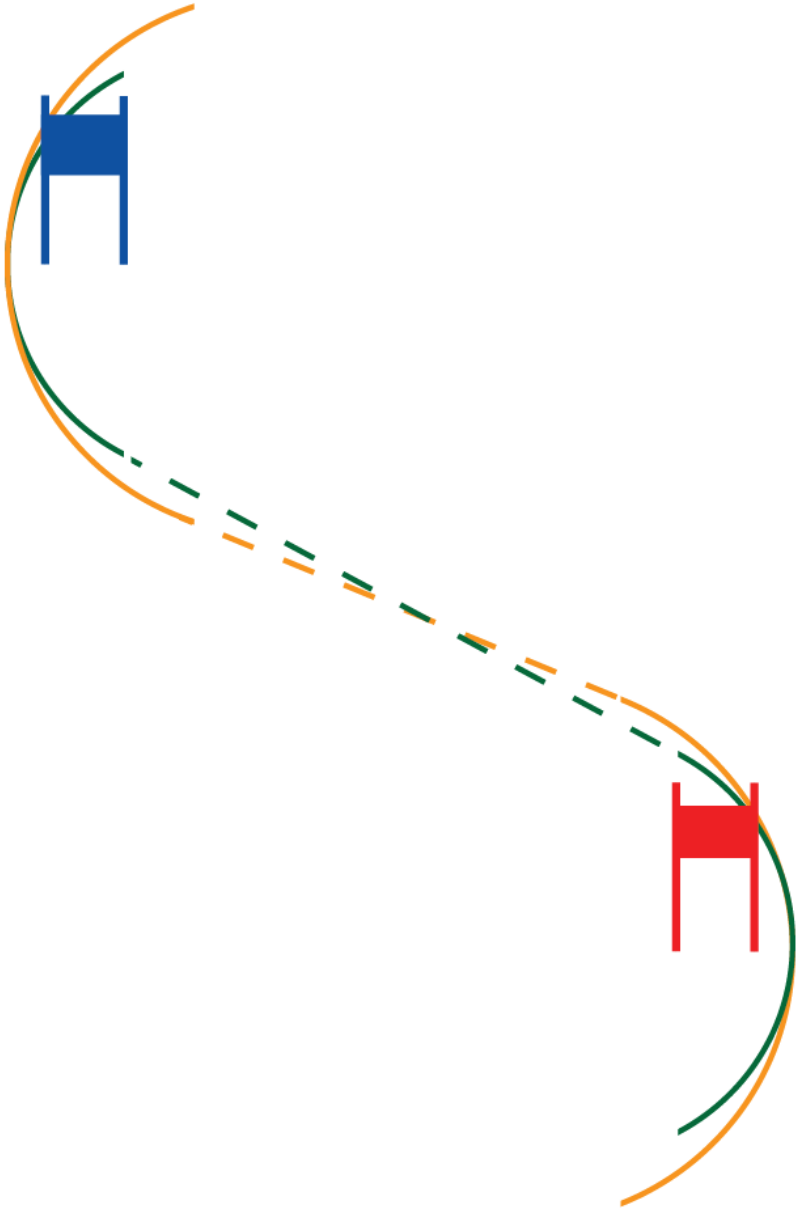

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