# PERFORMANCE MODEL

Performance Skiing
Situational Skiing
Additional Concepts
Novice & Intermediate

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# INTRODUCTION

Building on the foundation of Physics of Skiing and the components of ski control and movements presented in the Skills Framework, the Performance Model defines mechanics and skiing concepts specific to desired outcomes.

## The model is presented in four sections:

**PERFORMANCE SKIING** takes a detailed look at the mechanics within the parallel domain on prepared ski resort surfaces.

**SITUATIONAL SKIING** covers the all-mountain landscape of off-piste and the associated tactics.

**ADDITIONAL CONCEPTS** explores ideas related to and specific to skiing.

**NOVICE/ INTERMEDIATE** offers a prescriptive approach to facilitate fundamental understanding and delivery.

# PERFORMANCE SKIING

## PARALLEL TURN PRINCIPLES

### Introduction

The snow, through our skis, pushes us! Directing this force with intention determines our direction and enables speed control.

In the below discussion, we explore parallel turn principles considering this fundamental push from the snow, how the skis interact with it and the relationship between the skis and our centre of mass.

### Context

The focus is on general turn principles, through a wide lens.

A skier's body is non-rigid; we can change our shape and create and resist forces through muscular effort. However, to enable simplification of the topic, we will take a rigid body dynamics perspective rather than examine all of the body's movement options.

### TURN TYPES

We define two basic variations of the parallel turn: Drifted and Carved.

However, situational skiing in a constantly changing mountain environment doesn't always allow for an either/ or approach. We often assemble turns with a blend of both turns within a single turn. We often start a turn with drift and finish it in a carved state - an expert short turn, for example.

Even at the elite level of World Cup, a turn will often start drifted and finish carved, an intentional tactic to achieve a desired outcome in a specific situation.

Generally speaking, we consider Carved turns of higher performance than Drifted turns; the less drifted the turn, the higher the performance.

Turning forces in a drifted turn have two components: one slowing the ski and one making it turn. The greater the drift, the greater the slowing component. Less drift reduces the slowing component. With no drift - by definition, a purely carved turn - the slowing component is reduced to zero.

In a carved turn, the skier's momentum changes direction but not magnitude (direction changes, speed does not), assuming the elimination of outside factors (turning across the hill, snow and air friction).

Turns within the drifting continuum (more or less drift) are incredibly versatile and are generally more appropriate for situational skiing objectives (non-prepared surfaces). The vast majority of turns are drifted turns, even by expert skiers.

Carved turns are more suited to specific surface preparations and conditions. There is no sideways slipping or drifting of the skis and therefore, very little loss of speed. This sensation of ski efficiency provides a unique and exhilarating experience.

## Drifted Turns

- The ski will move sideways to differing degrees as it moves forward throughout the turn.
- The tail of the ski will travel a longer path than the tip; it will scribe a larger radius.
- The tail has more sideways displacement from the centre of the turn than the ski tip; it travels a greater distance. This oversteering action results in an extremely versatile turn.

## Carved turns

- The tail of the ski follows the tip. The front of the ski creates a track or groove through which the entire ski runs. They can be of limited versatility but are exhilarating.
- A ski is only capable of carving through a specific and limited radius window, as determined by its geometry. The upper limit is set by the sidecut radius. Refer to the Additional Concepts section where the carve radius window is described in detail.

## A GENERAL REPRESENTATION:

### Motion

- Gravity is pulling us towards the center of the planet.
- The snow provides the contact point from which the planet pushes back on us.
- The low friction contact point between the snow and the ski base facilitates a shear force component of gravity that produces motion.
- As gravity pulls us down the hill, we gather momentum. Direction, speed and balance control are manipulated via the interaction of the snow and our skis.
- We use our skis to scrub off speed and continuously deflect ourselves along a desired path as we descend.

### Turning

- Our skis being at an angle to the direction of travel (steering angle), tilted to the snow surface (edged), and our center of mass being inside of our outside ski, elicits a push force from the snow.
- Through resistive muscular effort, we balance against this reaction force from the snow.
- This reaction force (GRF) has a component that prevents us sinking into the ground and a turning force. In a drifted turn, a slowing and a sideways component creates the turning force.
- The sideways component, a centripetal force (which we feel as a centrifugal force), is what provides the turning magic.
- A component of gravity enhances turning forces as we turn towards the fall line, and detracts from them as we turn out of it ***
- Consequently, we feel less turning force early in the turn and more as the turn progresses past the fall line.
- The greater the centripetal force, the more inclination is required to maintain a favorable balance relationship with the snow reaction force (the balance line)
- There is a force balance equation at play: if we do not continue to incline as the turn progresses, our turn shape will elongate (drifted turn).

### Linking

- To transition from one turn into the next, our COM and BOS switch sides and our balance shifts from the current outside ski to the new outside ski.
- A metronome depicts the action of inclining from the inside of one turn to the other.
- A toppling action, through an intentional disruption of balance, provides the impetus to project us from one turn into the next.
- During the toppling action, body segments realign, the skis change edges and balance shifts against the new outside ski.

*** In the top of the turn, a gravitational component reduces the sensation of centrifugal force; at the bottom of the turn, this sensation is increased. Thus, the magnitude of turning forces can differ considerably at the top and the bottom of the turn.

## ADDITIONAL PERSPECTIVE:

**Virtual bump**

The action of turning on a slope causes the skis to speed up and slow down, due to the changing gradient under the skis (relative to the longitudinal axis), as their orientation changes relative to the fall line throughout a turn.

When the skis point across the hill (turn completion phase), the gradient is virtually non-existent and the skis slow down. Conversely, as the skis transition from across the hill to down the hill (turn initiation phase), they speed up.

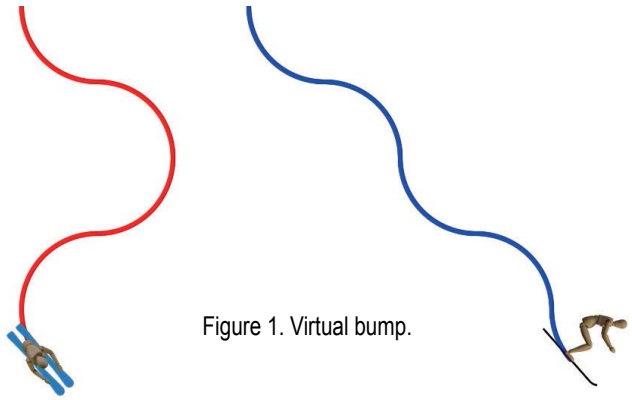

Figure 1. Virtual bump.

In the fore aft balance plane (sagittal plane), we must move appropriately to accommodate the speeding up and slowing down of the skis. Anticipation and an awareness of keeping up with the skis through the turn initiation phase is required to maintain ideal fore aft balance as the skis accelerate. Similarly, as the skis slow down, we must ensure we are not too far forward.

Modern ski design comprises aspects of self steering built into the ski. Self steering is addressed in detail in the Additional Concepts section. A tipped ski will turn as it moves forward, as the snow applies a greater force to the front of the ski than the tail.

In a Drifted turn, we can amplify or retard certain aspects of ski design. Applying more pressure to the front of the ski causes the front to grip more and the tail to slip (drift).

Executed with correct timing, application of pressure to the front of the ski can enhance the turning effect.

Applying more pressure to the tail of the ski reduces the tendency for the tail to break free (drift). Torque is decreased and more grip is created at the tail.

In drifted turns, enhancing turning forces at the start of the turn and increasing grip through the control and completion phases generally produces favorable outcomes.

**Ski to ski**

- We are bipedal (two-legged) creatures, but we are more effective skiers if we adopt a monopedal stance (single limb support against the outside ski)
- Certain situational skiing requirements and recovery actions aside, it is more effective and efficient to ski on the outside ski.
- In-rigger redundancy. Our inside ski can catch us if we fall too far, too quickly to the inside.
- Inside ski can control and manipulate our inclination
- Outside leg is more extended and therefore, stronger in the vertical plane (perpendicular to the ski base)
- Biomechanically stronger and more effective (alignment) at controlling turn forces.
- Maximizes grip. Greater edge angle and more pressure is produced on the outside ski
- We balance AGAINST the outside ski throughout the turn. Refrain from language and concepts referencing balancing “over” the outside ski from a technical perspective - it is incorrect. From a teaching tactic it may have its place depending on the situation and student. Specific language regarding balancing “over” the outside ski should be treated with caution always as learners often take us literally.

**Transition from limb to limb / foot to foot / ski to ski:**

- The gait cycle depicts weight transfer in skiing: just as our weight shifts from stance foot to stance foot when we walk, so do we shift our weight from outside ski to outside ski when we ski.
- Weight is first transmitted to the outside arch (lateral). As the foot structure bears weight, it tips to the inside (pronation). Pronation favorably focuses pressure on the inside edge of the outside ski

# TURN PHASES

## Introduction

A skier's path down the mountain is defined as a series of flowing turns controlling direction and speed. Turn phases provide the basis to study both turns and the linking of turns.

## Purpose

Turn Phases provide a frame of reference for professionals to more accurately describe and discuss turn mechanics. This mechanistic approach permits the breakdown of a complex system into simpler elements.

## Definition

- The turn model is defined by three phases.
- The turn phases are not three equal parts. The type of turn, terrain, and desired outcomes highly influence the timing and duration of each phase.
- Completion (end or release) phase.
- Initiation (start) phase.
- Control (middle or shaping) phase.
- The Completion and Initiation phases combine to seamlessly connect one turn to the next. We refer to the catenation of these two phases as the Transition.

## Why do we need it?

- To accurately describe the intent and outcome of specific parts of the turn.
- To provide a common vernacular to facilitate consistent, concise and accurate communication across the membership and between professionals.
- To maintain consistency in understanding. To enable accurate dialog and conversation.
- To clearly and accurately describe the actions of the skis on the snow (control actions), movement patterns (planes of balance) and skills applied in specific points within turns.

## How do we use it?

- To describe movement patterns, BOS & COM relationship, forces and the ski-to-snow interface with refinement and specificity.
- As a key component of the Assessment and Development toolkit.

## Completion

- The initiation of movements that project the COM into the new turn. Turn completion commences the moment the skier decides to start the next turn.
- A non-parallel skier will rise and start to pressure the uphill ski to change it to the new outside ski. The COM remains inside the BOS.
- A parallel skier will initiate a toppling maneuver to start a Toppling effect. The COM starts on a path that will ultimately cross the BOS.
- BOS/COM commencement of a convergent trajectory.
  Decrease of inclination.
- Forces - The reaction forces from the snow (GRF) on the COM start to decrease.
- SSI (Ski / Snow Interface) - edge angle decreases.
- Start of balance change from outside ski to outside ski.

## Initiation

- The turn initiation phase starts when the COM is directly above the BOS. The COM starts “falling” inside the turn arc.
- The skier judges how long to let their COM continue to fall before they “catch” themselves by steering (turning and edging) their skis (BOS).
- Body segments realign.
- BOS/COM commencement of a divergent trajectory. Increase of inclination.
- SSI - least friction of skis when flat on snow - least effort to redirect them.
- SSI - skis change edges (parallel turn).
- SSI - creation of steering and initial edge angle.
- Forces - force from the snow (GRF) starts to build.
- Start of balance against outside ski forces.

## Control Phase

- Skier COM is deflected in a positive direction change. Progressive skills usage to control turn shape.
- BOS/COM continuation of divergent path. Increase of inclination.
- Forces - The reaction forces from the snow (GRF), increases to largest magnitude.
- SSI - edge angle increases.
- Balancing against outside ski forces.

# DRIFTED TURNS

## OVERVIEW

### Medium/Long

The Drifted Parallel turn has more speed, both skis are turned at the same time and remain on corresponding edges. The track it leaves in the snow is narrower throughout turn initiation as no stemming is present. The COM moves inside of both skis as the new outside ski provides a balance platform due to an early commitment to the outside ski. A Drifted turn produces a Z type turn shape with more time spent across/out of the fall line.

### Short

Same mechanics as medium drifted turn but with adjustments to the skills, intensity and rate. Stronger leg turning with the addition of more upper and lower body rotational independence (counter rotation). The shorter the radius the more emphasis on quicker leg movements and a stable upper body come into play. The COM will take a slightly more direct path down the hill.

| TECHNICAL | Medium | Shorter radius / varying the size into a shorter turn |
|---|---|---|
| **Objective tactical** | Increased agility and efficiency with less effort. Ability to explore more terrain. A more natural stance. The goal of many skiers. | Ability to explore more terrain. Provide options to control and adapt to changes in the skiing environment - terrain. |
| | | Shorter turns are the gateway to advanced terrain - steeper runs, bumps, powder. |
| **Objective technical** | Both skis are turned at the same time and remain parallel throughout the turn. | Both skis are turned at the same time and remain parallel in a short radius skidded round turn. |
| **Eureka moment** | Ability to turn both skis together to start a tun | Ability to negotiate steeper and narrower situations in control - I'm in charge! |
| **Pre-requisite** | Intro to parallel turn - skis match before the fall line. Confidence to ski faster | Medium skidded turn competency. |
| **Fundamentals** | **Short version of mechanics** | |
| | Increase in speed. | Upper and lower body independence. |
| | Release COM over BOS. | Stronger and faster leg turning. |
| | Simultaneous edge release and turning of both skis. | Pole plant - optional but advantageous. |
| | Early weight shift to new outside ski. | |
| **Ski/snow interface** | Skis remain parallel. | |
| | Skis flatten and acquire equal weight as edge angle is reduced from the completion phase (Edging Control, Pressure Control). | |
| | The outside ski acquires the majority of the weight in the initiation phase. (Pressure Control). | |
| | Skis turn together into the new turn at turn initiation phase. (Rotational Control). | |
| | The skis continue to turn and grip through the middle and completion phases (Rotational and Edge control). | |

| TECHNICAL | Medium | Shorter radius / varying the size into a shorter turn |
|---|---|---|
| **Movements** | **Movements required to achieve the mechanics.** | |
| | Recentre COM over BOS through leg extension management. | |
| | Weight shift. Pressure will be directed to the outside ski by pressing (leg extension) on the old inside ski starting in the turn completion phase. This produces an up and across the skis movement and releases the edges as the COM moves over the BOS. | |
| | Turning effort. Leg rotation of both skis at the same time as the edges release. The rotational movements also aid balance against the outside ski. | |
| | Steering. Mostly leg rotation focused at this stage. | |
| | Steering. lowering of COM through flexion of all joints to aid in steering and balance. | |
| **Mechanics** | **Skis interactions with the snow and body movements** | |
| | **Transition:**<br>Completion phase; skis are parallel, skiers legs are flexed and weight is on the downhill ski. | |
| | Skier extends legs to recentre COM over BOS as weight is distributed between both legs. | |
| | Downhill pole swing is initiated - pole plant is optional at the drifted turn stage. | |
| | **Start/Initiation:**<br>Weight is transferred to new outside ski and the COM moves forward and across the BOS through leg extension management. Appropriate speed is required. | COM moves forward and a more down-the-hill movement direction in comparison to the medium radius turn. |
| | Pole is planted to assist weight transfer and aid in leg rotation. | |
| | Skis are turned simultaneously into the new turn through leg rotation. | |
| | Grip from the outside ski provides a balance platform through a combination of inclination and angulation. | At a faster rate and intensity to the medium radius turn. |
| | **Middle/Control:**<br>Balance is maintained on the outside ski and COM is inside the BOS. | |
| | The ski path produced is a Z type turn, the skis spend little time pointing down the fall line, more time spent across/out of the fall line. | |
| | Flexing in all joints helps to continually guide and balance on the outside ski. | |
| **Physics** | External force utilization to enhance lower body steering; a correctly timed pole plant and/or inside pole drag create an external contact point with the ground (snow surface). This effectively provides an external force that can be exploited through internal muscular activation to enhances lower and upper body independence. | |

| TEACHING | Medium | Shorter radius / varying the size into a shorter turn |
|---|---|---|
| **Terrain** | Groomed green/blue terrain. Consistent and predictable surface layer. Convex terrain helps with turn initiation. Use natural terrain features, such as very small bumps and rollers, to assist with rotational actions of the skis. | |
| **Safety** | Stay away from, or work with the flow of traffic. Teach responsibilities and risks of being on the mountain. Watch for fatigue as short turns require more energy to perform. | |
| **Equipment considerations** | Frontside or all mountain skis. Edges should be in good condition ensure sufficient grip and feedback. | |
| **Tactical considerations** | **Tactical choices skiers make to achieve a goal. Decisions are based on environmental context and desired outcomes.** | |
| **Additional notes** | A pole plant can assist with the releasing of both edges. It helps with timing and balance (committing to new outside ski) and enhances internal turning effort (point of contact with the ground). However, as the pole plant can be difficult to acquire at the drifted turn competency, we consider it optional as part of a drifted turn. | |
| **TEACHING FOCUS** | Ski at speeds that allow for parallel skiing. | Varying the intensity and rate of rotational and lateral balancing movements, during a specific phase of or throughout the whole turn. |
| | Develop an early weight shift action to new outside ski. | |
| | Develop simultaneous edge release and leg turning. | |

# STEERED TURNS

## OVERVIEW

### Medium/Long

In comparison to the Drifted turn; the Steered medium turn has more speed, edge angle, grip and direction control. The track it leaves in the snow is narrower due to stronger edging and use of the skis geometry. The COM moves into the new turn with more conviction. Higher centripetal force allows the COM to travel laterally further inside the turn, due to the increase in speed and more grip created from stronger edging movements earlier in the turn. Turn shape is rounder (more time spent in the fall line) in comparison to the Drifted turn.

### Short

Same mechanics as a medium steered turn but with adjustments to the skills timing, intensity and rate. Stronger/faster leg turning, edging and pressure, with the addition of more upper and lower body rotational independence (counter rotation). The path of the COM will take a more direct route down the hill.

| TECHNICAL | Medium/Long | Short |
|---|---|---|
| **Objective tactical** | Increased ability and confidence to explore more terrain, with higher performance and control through a rounder turn shape. | Ability to command steeper terrain, narrow sections and firme snow. |
| **Objective technical** | Skis remain parallel and are steered with grip continually throughout the turn. | All mountain versatility and a more dynamic turn. |
| **Eureka moment** | First power steering moment - ski performance experience. Feeling solid grip before the fall line. | I can ski anywhere realization |
| **Prerequisite** | Drifted turn competency / confidence to ski faster | |
| **Fundamentals** | **Short version of mechanics** | |
| | Increase in speed. | Upper and lower body independence / separation. |
| | Active COM crossover. | Stronger leg turning. |
| | Early and committed weight shift to new outside ski. | Early edging. |
| | Stronger leg turning and edging of both legs/skis. “Slower” leg turning at initiation and “stronger” through the Control/Middle Phase. | Progressive edging and leg turning. |
| | Progressive edging of both legs/skis (angulation). | Greater active pressure control (absorbsion). |
| | Flexion & extension movements control pressure from ski to ski, and aid with steering efficiency. | |
| | Pole plant is cool! Aids with timing and feel (snow/pole contact allows body to know where it is in comparison to the slope). | Blocking pole plant. |
| **Ski/snow interface** | In addition to the Drifted turn ski/snow interface | |
| | The path of the tail generally follows the tip through all turn phases. | |
| | Skis are edged earlier and achieve higher edge angles throughout the turn (edge control) | |
| | Ski design is utilized throughout the turn | Ski design is utilized throughout the turn |

| | | |
|---|---|---|
| **Movements** | **Movements required to achieve the mechanics.** | |
| | Recentre COM through leg flexion/extension management. | Tightening of radius can also come into play. |
| | Commitment of COM into the new turn (crossover) through leg extension and inclination. | |
| | Weight shift. Pressure will be directed forward and towards the outside ski through leg extension (knee extension moves COM forward). | |
| | Steering. Blending of leg rotation and edging (ankle, knee and hip angulation) movements continue progressively throughout the turn. | |
| | Steering. lowering of COM through greater lateral flexion of leg/hip joints to aid in steering and balance. | |
| **Mechanics** | **Skis interactions with the snow and body movements** | |
| | **Transition:**<br>Completion phase; skis are parallel, skiers legs are flexed and weight is on the downhill ski. | Higher edge angle. |
| | Initiate pole swing. | |
| | Increased speed aids transition into the new turn. | |
| | Skier extends outside leg to recentre and COM crosses over the skis into the new turn with some inclination. | Blocking pole plant. |
| | **Start/Initiation:**<br>Weight is transferred to new outside ski and the COM moves forward through leg extension. | COM moves with an active forward and a down-the-hill movement direction in comparison to the medium radius turn. |
| | Skis are steered into the new turn through leg rotation and edging movements. | At a faster rate and intensity to the medium radius turn. Creates a larger steering angle. |
| | Grip from the outside ski provides a stable balance platform. | |
| | **Middle/Control:**<br>Progressive and continued steering is achieved by a combination of leg rotation and edging movements. | |
| | Balance is maintained on the outside ski as the COM moves more inside the turn due to higher turn forces (centripetal force). | |
| | **End/Completion:**<br>Flexing in all joints helps to continually guide and balance on the outside ski. | Active absorbsion (pressure control) in the completion phase t deal with increased push back from the snow (forces). Facilitates stable COM path. |
| **Physics** | External force to utilization to enhance lower body steering; a correctly timed pole plant and/or inside pole drag create an external contact point with the ground (snow surface). This effectively provides an external force that can be exploited through internal muscular activation to enhances lower and upper body independence. | Due to the increased rate of turning the skis (rotational control), the angle of the slope rapidly increase at turn initiation. Keeping up with the skis and maintaining balance (balance line) requires a more aggressive forward movement at turn initiation (fore af pressure control). |
| | In comparison to the Drifted parallel turn, greater centripetal force will allow the path of the COM to move more inside the turn. | A strong pole plant (external blocking force), and counter rotation create a stable upper body mass which to turn the legs against. |

| TEACHING | Medium/Long | Short |
|---|---|---|
| **Terrain** | Wide groomed blue terrain. Consistent and predictable surface layer. | Use natural terrain features, single groomer track. |
| **Safety** | Skiing faster and with more edging increases forces on the skier. Be aware of the physical exertion and watch for signs of fatigue. | Considerably more physical. Watch for fatigue as short turns require more energy to perform. |
| **Equipment considerations** | Frontside or all mountain skis. Edges should be in good condition to ensure sufficient grip and feedback. | |
| **Tactical considerations** | **Tactical choices skiers make to achieve a goal. Decisions are based on environmental context and desired outcomes.** | |
| | Options exist to vary turn size, mechanics remain consisten but rate of movements change to manipulate turn shape and size. | |
| **Practical considerations** | Individuals that are creating lower leg edge angles but still find it difficult to grip may benefit from some outward lateral canting of the boots. | |
| **TEACHING FOCUS** | Develop intensity of rotational and lateral (edging) movements to create grip throughout the turn. | Faster intensity and rate of leg rotation. Quicker tempo. |

# CARVED TURNS

## OVERVIEW

### Medium/Long

In comparison to the Steered turn the Carved medium/long turn has increased speed, edge angle, grip and forces. The tracks left in th snow are clean narrow grooves. The turns are dictated purely by the ski design and geometry and the tails perfectly follow the path of the tips. Due to the increase in speed and forces (higher centripetal force), the COM travels laterally further inside the turn.

### Short

Similar mechanics as a medium carved turn but with adjustments to the skills intensity and rate. Increased intensity of edge engagement and pressure. More upper and lower body rotational independence (counter rotation). The path of the COM takes a more direct route down the hill. Tail of the skis follows same path as the tips.

The carved short turn cannot maintain speed control on steep terrain. It is suited more to speed maintenance on lower angle pitches. As the pitch increases the turn radius will be too large and COM path too direct down the hill to maintain a consistent and controlled decent. To maintain speed control an initial steering angle is required to shorten the radius of the turn - and in effect a steered short turn is produced. It should be noted that even at the elite level (World Cup SL) steered turns are utilized often on the steeper pitches.

| TECHNICAL | Medium/Long | Short |
|---|---|---|
| **Objective tactical** | Expert level skiing. Fast, high performance output . Racing. Maintenance of speed during turn deflection and direction changes. | |
| **Objective technical** | Turn shape is greatly reliant on ski design and geometry. The tracks left in the snow are carved grooves. | |
| **Eureka moment** | Clean narrow lines scribed into the snow surface. Pure forward propulsion of the skis. Sensation of G-forces. | Elite skiing performance. Will the sponsors contact me…? |
| **Prerequisite** | Steered turn competency on black runs. Desire to ski faster with more forces | Carved medium and Steered short turn competency |
| **Fundamentals** | **Short version of mechanics** | |
| | Active COM crossover. | More direct down the hill COM crossover path. Active absorbsion of pressure through transition. |
| | Immediate engagement of inside edges (lock skis on edge). | |
| | Progressive increase in edge angle (work ski design). | Faster rate of edging. More leg angulation, less hip angulation. |
| | Pressure control management to regulate forces and balance line. | Much faster rate of pressure control movements to remain stable. |
| **Ski/snow interface** | The path of the tail perfectly follows the tip through all turn phases. No lateral slipping of the ski. | |
| | Skis are edged earlier and achieve higher edge angles throughout the turn (edge control). | |
| | Ski design is the primary mechanism of direction change. Increasing the skis edge angle shortens the skis turn radius. | |

| | | |
|---|---|---|
| **Movements** | **Movements required to achieve the mechanics.** | |
| | Active crossover of COM through leg flexion/extension management. | Active absorbsion through transition due to rapid build up of pressure. COM stays low. |
| | **Edging.** Active ankle and knee angulation place skis on edge as COM moves over skis to inside of turn. | |
| | **Edging**. Pressure. Outside leg extends to continue COM progressively moving inside of turn<br>- Inside leg flexes to allow COM to progressively move inside of turn.<br>- Hip Angulation. Hips move more inside of turn. Upper body moves towards the outside and facing direction of travel. | Faster rate of progressive edging. |
| | **Pressure control.** Leg extension and flexion (eccentric contraction) regulates ski forces and balance line throughout turn | |
| | | |
| **Mechanics** | **Skis interactions with the snow and body movements** | |
| | **Transition:**<br>Increased speed aids transition into the new turn. | |
| | Initiate pole swing. | |
| | Simultaneous leg flexion (downhill ski) /extension (uphill ski) management to transition COM over the skis and actively into the new turn. | Active absorbsion/retraction movements (pressure control) to deal with forces. |
| | Probable that both legs flex with the Uphill leg keeping slightly more resistance to initiate/create the crossover/toppling effect. | |
| | **Start/Initiation**:<br>Weight is transferred to new outside ski and the COM moves forward and inside as the outside leg extends. | COM moves with an active forward and a more downthe-hill movement direction in comparison to the medium radius turn. |
| | Leg edging movements guide the skis directly onto the new edges. | |
| | Grip from the outside ski provides a stable balance platform. | At a faster rate and intensity in comparison with the medium radius turn. |
| | **Middle/Control:**<br>Progressive and continued edging movements - leg length independence and hip angulation. | Strong outside leg extension. |
| | Balance is maintained on the outside ski as the COM moves more inside the turn due to higher turn forces (centripetal force). | COM moves less inside than the carved turn due to less speed and time. |
| | Outside leg posture remains strong to regulate ski forces. | |
| | **End/Completion:**<br>Edge angle management dictates turn shape. | Upper and lower body rotational independence. Upper body and core discipline. |
| **Physics** | In comparison to steered parallel turn, greater centripetal force will allow the path of the COM to move more inside the turn. | Due to the shorter turn radius and tempo. Keeping up with the skis and maintaining balance (balance line) requires a more aggressive forward movement at turn initiation (fore aft pressure control). |
| | Outside ski needs to be tilted equal to or more than the inclination of the skier (frontal view) or the ski will slip in firm conditions. | |
| | Grip = Outside ski edge angle >= Inclination of skier. Outside ski is tipped over more than the skier leans in (visual this concept from frontal view). | |

| TEACHING | Medium/Long | Short |
|---|---|---|
| **Terrain** | Initially on green terrain for edge locking (railing). Progress to steeper terrain as student ability increases. Consistent and predictable surface layer. | Flatter terrain sections. Carved short turns do not provide a turn shape appropriate for speed control on steeper terrain. |
| **Safety** | Fast skiing and large forces. Ensure physical and phycological readiness. | |
| **Equipment considerations** | Frontside, All mountain or Slalom skis. Initially, a slalom style ski due to its shorter radius can be beneficial as the ski pushes back on the skier at a faster rate. This provides a more obvious and quicker ski geometry feedback mechanism which is critical to learn a pure carved turn. | Slalom ski preferred. |
| **Tactical considerations** | **Tactical choices skiers make to achieve a goal. Decisions are based on environmental context and desired outcomes.** | |
| | Options exist to vary turn size, mechanics remain consistent but rate | Provides the ability to maintain speed on flat terrain, or narrow corridor at high speed, in a short turn radius. |
| | | An active retraction motion of the legs will often be required to deal with the forces at play to keep the COM on a smooth trajectory into the new turn |
| **TEACHING FOCUS** | of movements change to manipulate turn shape and size. | Faster intensity and quicker tempo. |

# ADDITIONAL CONCEPTS

## SELF STEERING

### THE SKI

Boots and skis are the tools we use to manipulate the forces from the snow to obtain desired outcomes. We control our boots and skis using our muscles and skeletal system. The snow pushes on us through our skis. The skis turn first and in turn, turn us. But the skis also help us turn in other ways.

Our skis are smart. They use forces from the snow and through specific design features, turn themselves.

Tipping the skis along their longitudinal axis while applying a force enables the self-steering property of the skis described below.

**Sidecut and longitudinal flex:**

Sidecut and longitudinal flex are design features of the ski that invoke the self-turning action. They provide us with a ski induced steering angle.

Sidecut describes the curved shape along the edge of the ski seen when viewed from above. It provides a slight steering angle along the forebody of the ski in relation to the ski's longitudinal axis. This design feature provides a steering angle in the transverse plane.

A ski is wider at tip and tail and narrower underfoot. This hourglass shape allows the ski to flex along its length when tipped on edge, bending the tip and tail around the centre of the ski. This longitudinal flex puts the front of the ski at an angle relative to the line of travel. This design feature provides a steering angle in the transverse plane.

The more pronounced the sidecut and deeper the flex, the greater the steering angle.

**Drifted turns.**

The snow pushes on the ski at slightly different angles along its length due to the curved shape of the sidecut.

The front of the ski is at a greater angle than the tail relative to the line of travel. A progressive reduction in steering angle takes place along the length of the ski from tip to tail.

The greater steering angle of the ski forebody provides more resistance. More sideward force is exerted on the front of the ski than the tail, producing a torque* on the ski. This torque generates a slight turning force independent of the skier's actions (the tendency of a force to rotate a body - the ski in this case).

** (the tendency of a force to rotate a body - the ski in this case).*

**Carved turns**

As a ski bends (longitudinal flex) and carves, it cuts a track in the snow, with the tip, mid-section and tail of the ski following the same curved track. The track that the forebody cuts into the snow creates a steering angle as it is slightly across our line of travel.

The ski leads the turning effort. Trajectory is primarily controlled through edge angle. The greater the edge angle of the ski, the more it bends and the tighter an arc it will carve.

Fore-aft pressure distribution along the length of the ski enables fine tuning of the sagittal plane steering angle through small adjustments of the ski's flex. Greater ski forebody pressure increases steering angle, creating a tighter arc. Reduced pressure on the forebody reduces relative steering angle, widening the arc.

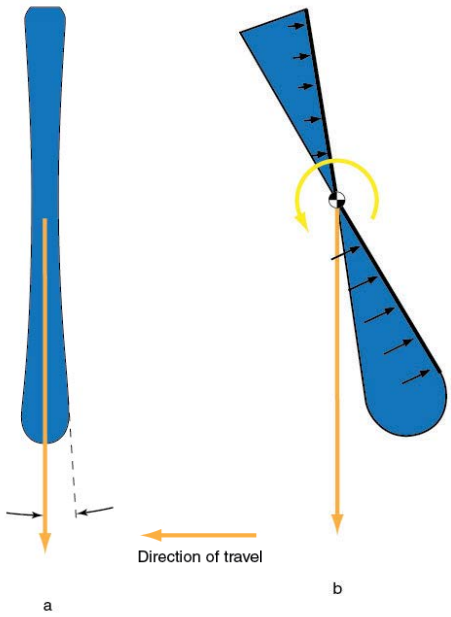


*Figure 3.*
*Because of its sidecut, a ski's steering angle in the transverse plane varies along its length. As a result, if edged even slightly, it will turn itself as it moves forward.*

*(a) A curved sidecut gives a ski its greatest steering angle at the tip.*

*(b) This ski with an angled sidecut will still turn itself, and shows clearly how the torque that makes it turn is created.*

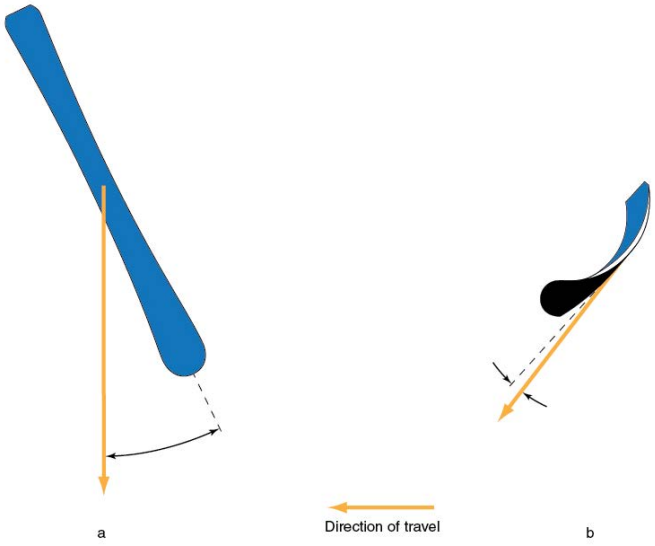


*Figure 4.*
*The ski can have steering angles in both the transverse and sagittal planes.*


*Figure 5*
*Longitudinal flex – sagittal plane steering angle.*

| NOVICE & INTERMEDIATE | |
|---|---|
| **A PRESCRIPTIVE BEGINNING** | **In the early stages of ski development, students must learn the fundamental concept that skiing is about manipulating a tool: the ski. Novice skiers must also learn to view their body as independent segments (ex. the legs turn the skis). At this level, a focus on ski control through independent body movements should be a tenet of the lesson plan delivery. There are few situations in life where we must balance atop a moving object; skiing is one of the experiences that provide this sensation/possibility.** |
| **First experience** | Meet, greet and move. Ensure students gain comfort and mobility in the snow environment. |
| **Gliding** | The sensation of gliding and letting go in a straight run. |
| **Snowplow** | Speed management in a snowplow stance. |
| **Linked snowplow turns** | Direction changes and control in a snowplow. |
| **Intro to parallel** | Matching of skis during a turn: at first, below the fall line and then progressing to above the fall line as competency increases. |
| **Parallel** | Students ski with more agility and efficiency by releasing edges and turning both skis at the same time. |
| **Pole plant** | A pole plant assists with balance and linking of turns. Optional at Drifted, mandatory at Steered. |

# NOVICE & INTERMEDIATE

## FIRST EXPERIENCE

### OBJECTIVE:

Meet, greet and move! Relationship begins with your students and goals are established. Students gain comfort and mobility in the snow environment.

“The time you take to greet your group, establish goals, and put students at ease is the foundation that the rest of your lesson will build upon.

This relationship and trust will help your students build the confidence to try new things and persist when learning a new sport”.

*Note that these are examples of lesson plans. Determining which is the best one to begin with depends on what your student’s needs are. Common Problems and Solutions below, will provide a few examples.*

### TERRAIN:

**As flat as possible.**

First meeting may be at the Rental Shop, Snow School Desk or Meeting Area.

### SAFETY:

Ensure students are dressed for the weather, fitness levels, input from parents about their kids’ needs.

### FUN FACTOR:

Energy and attitude! Smile, be authentic, get to know your students. Keep them moving. Tune the intensity level to fitness level.

### FUNDAMENTALS

- Meet, greet
- Trust and confidence
- Equipment familiarization
- Use of all joints helps maintain balance
- Climbing a small slope
- Turning safely to glide down

### LESSON PLAN EXAMPLE

1. Meet and greet your students with energy. Be approachable and learn names
2. Find out how they feel, listen for apprehension
3. Find location to introduce them to the environment, equipment and start mobility
4. Create mobility through walking over various terrain, running, races, tag…
5. Introduce equipment, how to put on, take it off
6. Show how to fall over safely and how to get up
7. Climbing (side stepping and/or herringbone)
8. Start gate stance (bullfighter turn) – to setup safely for gliding

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Fear and Apprehension:** | |
| **Assessment:** | Hesitant to try, they look nervous, they may be afraid (falling, other skiers etc.) |
| | kids may cry, refuse to go with you |
| **Development:** | Be friendly, open and helpful to build trust and confidence |
| | Prime them for the fun they will have. Falling is part of it and it's okay! |
| | Stay close to them for support and comfort |
| | Get down to kid's eye level, goggles up, smile, talk about things that interest them |
| **Lack of mobility:** | |
| **Assessment:** | Show them heel to toe stride in ski boots, dig heels or toes in on slopes |
| **Development:** | Have them bounce up and down to flex boots |
| | Work on moving all joints, use examples like tennis, basketball etc. |
| | Keep group active to keep them warm, take breaks if needed |
| | Play games with kids |
| **Can't climb slope:** | |
| **Assessment:** | Skis slipping and not gripping enough |
| **Development:** | Roll ankle and knee of downhill ski inwards, so the edge bites |
| | Ensure they understand the effect of the "fall line" |
| **Difficulty turning around on a slope:** | |
| **Assessment:** | Hesitant or lack of correct movements to turn in place on a slope |
| **Development:** | Bullfighter turn |
| | Small multiple steps to maneuver skis into snowplow position |
| | Hands-on approach, you can assist students the first few times as they move to their start gate stance |
| **Equipment:** | |
| **Assessment:** | Incorrect use or setup of equipment, awkward handling, confused looks, boots hurt |
| **Development:** | Check that boots are done up correctly, pants over boots, not tucked inside etc. |
| | Teach to scrape snow off on bindings and assist when needed |
| | Not everyone can afford the right equipment. Be empathetic with recommendations |
| | Show how bindings function and how to get in and out of them. Practice... |
| | Ensure bindings fit boots, but don't adjust bindings yourself |

# GLIDING

## OBJECTIVE:

Students can glide and are confident with the sensation of “letting go.”

### TERRAIN:

**Flat or gently sloping.**

Concave or slight rise in outrun is ideal.

### SAFETY:

Consider how fast the students might go without ability to slow or stop themselves. Are there hazards?.

### FUN FACTOR:

How far can you slide? How fast can you go?

How about one foot? Jumping while sliding.

## FUNDAMENTALS

- First sensation of gliding
- Use of all joints helps maintain balance
- Balance on the foot

## MOVEMENTS

- n/a
- Use range of movement in ankles, knees and hips
- Flexed ankles, shin contact, ball and heelpad

## LESSON PLAN EXAMPLE

1. Show and have them try an athletic, centred stance before sliding.
2. Help them find cues such as shins on tongue of boots, weight in middle of each foot.
3. Push with poles to start sliding.
4. Maintain bend in all joints for balance, look forward, hands forward with arms relaxed.
5. Explore range of movement by utilizing joints.

## COMMON PROBLEMS AND SOLUTIONS:

| Fear and Apprehension: | |
|---|---|
| **Assessment:** | Hesitant to try, they look nervous, they may be afraid (falling, other skiers etc). |
| | Falling backwards when skis move. |
| **Development:** | Stay close as they try, offer a hand or snowplow backwards in front of them. |
| | Consider flatter terrain. |
| **Falling:** | |
| **Assessment:** | Unbalanced stance, lack of flexion. |
| **Development:** | Hands on knees for stability, shin pressure, go with the skis. |
| | Balance on both feet, drag poles to assist balance. |

**Additional Information**

Gliding is the essence of skiing. Don’t underestimate the exhilaration that a student will feel at this point in the lesson.

# **SNOWPLOW:** SPEED MANAGEMENT IN SNOWPLOW

## OBJECTIVE:

Students can confidently manage their speed using a snowplow stance.

### TERRAIN:

**Flat to gently sloping.**

Concave or slight rise in outrun is ideal.

### SAFETY:

Consider how fast the students might go if they aren't successful. Are there hazards (trees, lifts, people)?

### FUN FACTOR:

Excitement builds with control. Red Light/ Green Light, slow races, use rollers – maintain speed.

### FUNDAMENTALS

- Wide stance
- Turn legs inwards
- Blend above movements

### MOVEMENTS

- (leg abduction)
- (internal leg rotation)
- (unification into a motorpattern)

### LESSON PLAN EXAMPLE

1. Demonstrate fundamental movements and how the snowplow works.
2. Have them try without skis on. One foot then the other. Jump into snowplow stance.
3. With skis on and some forward movement, turn skis into snowplow.
4. From a downhill glide, have them try a snowplow. Ensure run out is clear.
5. Vary by adding games and challenges for quickness and control.

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Tips cross:** | |
| **Assessment:** | Tips touching or crossing. |
| **Development:** | Move feet wider apart, ski down backwards and help them, use of Edgie-Wedgie. |
| | Flex down as feet move apart, use muscular effort to maintain snowplow. |
| **Tips separate:** | |
| **Assessment:** | Tips too far apart. Legs don't turn in. |
| | Student is sitting back. |
| **Development:** | Teach balance on inside of each foot. |
| | Ensure student is turning legs in, ankles are bent, and they feel shin contact on boots. |
| **Tips separate:** | |
| **Assessment:** | Students begin to fall more frequently, possible frustration. |
| **Development:** | Limit amount of climbing, take breaks. |
| | If safe to do so, use surface lift or stationary carpets. |
| | Promote relaxed posture, tension burns energy |

# **SNOWPLOW:** DIRECTION CHANGE AND LINKING SNOWPLOW TURNS

## OBJECTIVE:

Students can change direction “at will” in a snowplow. Excitement builds with control!

### TERRAIN:

**Gently sloping with space to link a few turns.**

Momentum is an important tool here.

### SAFETY:

Consider where students might go if they make a mistake. Are there hazards (trees, lifts, people)?

### FUN FACTOR:

Ski pole slalom, Simon says, cat and mouse, terrain features, use a lift if you can.

### FUNDAMENTALS

- Skis in snowplow
- Turn outside leg/foot
- Balance on outside ski
- Change of balance

### MOVEMENTS

- (basic snowplow position)
- (internal femur rotation)
- (lighten inside foot)
- (re-centering, flexion and extension of legs)

### LESSON PLAN EXAMPLE

1. Same fundamentals as straight snowplow. Now use one side more than the other.
2. From a snowplow, rotate femur of outside ski and lighte the inside foot. Balance on outside foot as it turns.
3. Try turn in other direction, turn to a stop in both cases.
4. Vary quickness and amount of movement for control.
5. Explain and practice how to re-center and transfer balance from outside ski to outside ski by making inside foot light.
6. Slide across the slope, rise and flatten old turning ski and then roll foot and turn new leg, maintain momentum.

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Student doesn't turn, leaning in:** | |
| **Assessment:** | Balance is on the inside foot. |
| **Development:** | Teach balance on outside foot. |
| | Flex ankle and knee of the outside leg, gentle tail tap of the inside ski, touch knee on outside leg. |
| **Doesn't turn:** | |
| **Assessment:** | Outside ski stuck on too much edge, ski will track with sidecut and leave a line in the snow. |
| **Development:** | Teach balance on inside edge of outside ski. |
| | Side stepping uphill to get feeling of inside edge, touch outside knee. |
| **Doesn't turn:** | |
| **Assessment:** | Outside ski stuck on too much edge, ski will track with sidecut and leave a line in the snow. |
| **Development:** | Narrow stance, flatten outside ski. |
| **Turns don't link:** | |
| **Assessment:** | Student won't/can't initiate new turn. |
| **Development:** | Develop re-centering movement and turning of new ski.<br>Rise up on both feet while extending, roll outside ankle inward. |
| **No control of turn shape:** | |
| **Assessment:** | Upper body leading the turn, outside ski not gripping |
| **Development:** | Work on leg turning (femur rotation), rolling in of the ankle on the turning ski. |
| | Turn thigh with hands, bottle cap analogy, focus on turn completion. |

# INTRODUCTION TO PARALLEL

## OBJECTIVE:

Students can glide confidently with enough speed to aid balance to the outside ski after the fall line.

### TERRAIN:

**Longer green to blue slope for medium speed.**

Consider confidence and athleticism of student.

### SAFETY:

Stay away from, or work with the flow of traffic. Teach responsibilities and risks of being on the mountain.

### FUN FACTOR:

Explore terrain, one ski turns, follow me, terrain features and turn shapes.

## FUNDAMENTALS

- Smaller snowplow
- Faster speed
- Inside ski edge change
- Inside ski steered to match
- Complete turn with parallel skis

## MOVEMENTS

- n/a
- n/a
- (lighten inside foot and roll to opposite edge)
- (inside ski external leg rotation)
- n/a

## LESSON PLAN EXAMPLE

1. Add speed to linked snowplow turns through a larger turn, comfortable terrain.
2. Below the fall line make the inside foot lighter to promote balance to outside ski.
3. Lighten inside foot and roll to opposite edge.
4. Based on student ability, progress inside foot lightening and rolling further up the arc.
5. Ensure enough speed and momentum to promote good balance..

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Speed not maintained:** | |
| **Assessment:** | Students can't roll inside ski onto uphill edge, tail of inside ski catches on snow, snowplow is too big. |
| **Development:** | Choose flatter terrain, encourage smaller snowplow and faster speed. |
| | Tap the tail of inside ski to promote balance on outside ski<br>Use "follow me" to promote effective turn shape. |
| **Tipping inside:** | |
| **Assessment:** | Skis not matching, balance on inside foot. |
| **Development:** | Teach balance on outside foot. |
| | Touch downhill knee with hands, one ski turns, airplane turns. |
| **No control of turn shape:** | |
| **Assessment:** | Upper body leading the turn, outside ski not gripping. |
| **Development:** | Work on leg turning, rolling in of the ankle on the turning ski. |
| | Turn thigh with hands, boot arch's in snow, bottle cap analogy, drag outside pole. |
| **Difficulty matching ski:** | |
| **Assessment:** | Balance on inside ski, skier is tipped inside. |
| **Development:** | Start lightening inside ski earlier in turn. |
| | Step-up turns, bike pedaling, rollerblade turn. |

**Additional Information**

With athletic students, faster speed on gentle terrain can naturally produce inside ski matching later in the turn. Encourage this and have the student reflect on what happened (skis are now on corresponding edges).

# LINKING PARALLEL TURNS:

**Refer to Drifted turns for detailed Mechanics**

## OBJECTIVE:

Students ski with more agility and efficiency by turning both skis at the same time

### TERRAIN:

**Green and blue runs.**

Consider confidence and athleticism of student. Convex rolls help turn initiation.

### SAFETY:

Stay away from, or work with the flow of traffic Teach responsibilities and risks of being on the mountain..

### FUN FACTOR:

I'm parallel skiing for the first time! Follow me, terrain features and turn shapes, increase speed.

## FUNDAMENTALS

- Slightly faster speed
- Recentre COM over BOS
- Simultaneous edge release and turning of both skis
- Balance to outside ski

## MOVEMENTS

- n/a
- Through leg extension
- Roll ankle inward
- Separation, angulation, rotation of femurs, roll foot inward

## LESSON PLAN EXAMPLE

1. Beginning at previous turn completion
2. Recentre COM over BOS through leg extension management
3. Edges release simultaneously with crossing of COM over BOS
4. Incorporate leg turning to promote balance on outside ski
5. Balance on outside ski throughout turn by keeping inside foot light
6. Increase edge angles with separation and angulation as required for direction and speed management

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Too slow:** | |
| **Assessment:** | Students speed too slow to execute a parallel turn |
| **Development:** | Choose flatter terrain to encourage faster skiing |
| | Have student follow you and keep up, encourage larger turns |
| **Late balance transfer:** | |
| **Assessment:** | Student stemming, COM not rising at turn initiation |
| **Development:** | Lighten inside foot to transfer balance earlier in the turn (turn initiation) |
| | Stork turns, drag uphill pole, berms or sidehills |
| **Not releasing both skis together:** | |
| **Assessment:** | Stemming, sequential foot movements |
| **Development:** | Practice simultaneous edge release |
| | Side slips on and off, focus on release of downhill ski, use convex terrain, rollerblade turns on flats |
| **No control of turn shape/speed:** | |
| **Assessment:** | Upper body leads into the turn |
| **Development:** | Work on leg turning |
| | Leg turning exercises, hockey stops, diagonal side slips |

**Additional Information**

Speed is important. It's very difficult to turn the skis simultaneously at slow speeds

A pole plant can assist with the releasing of both edges. It helps with timing and balance (committing to new outside ski) and enhances interna turning effort (point of contact with the ground)

*COM = Center of Mass, * BOS = Base of Support

# POLE PLANT:

**Only applicable if your students have poles and learning a pole plant will be beneficial to development.**

## OBJECTIVE:

Students ski with more agility and efficiency by turning both skis at the same time

### TERRAIN:

**Green and blue runs.**

Teach pole plant on terrain that students are very comfortable with

### SAFETY:

Pole straps adjusted correctly to protect the thumb

### FUN FACTOR:

A secret weapon for our skiing

## FUNDAMENTALS

- Arms forward, slightly to side
- Swing downhill pole from forearm and wrist
- Timing of pole touch is at edge change

## LESSON PLAN EXAMPLE

1. Stationary practice of pole swing and touch. Only swing with forearm and wrist. Arms stay quiet
2. Create a light inside foot with the timing of the pole plant
3. Practice above sequence in a traverse or on a cat track
4. Apply to turns

## COMMON PROBLEMS AND SOLUTIONS:

| | |
|---|---|
| **Planting wrong side:** | |
| **Assessment:** | Planted on uphill side |
| **Development:** | Explain correct side |
| | Have student follow and copy/mirror you |
| **Incorrect timing:** | |
| **Assessment:** | Timing not at edge change |
| **Development:** | Time pole swing with the rising motion (leg extension) |
| | Stork turns, step-up turnsv |
| **Loss of separation and balance:** | |
| **Assessment:** | Upper body rotates around with pole swing, inside hand/arm falls back |
| **Development:** | Swing pole only with forearm and wrist - not arm |
| | Keep/push hand forward after pole touch, keep hands in view, double pole plant |

**Additional Information**

A pole plant is necessary to progress to advanced skiing. It improves balance by creating a larger base of support, helps with timing, stabilizes upper body and can enable a stronger turning force in the legs.

A pole plant can be taught before or after Parallel.