THE SCIENCE OF SKIING

GOAL: To develop the ski teacher's ability to apply movement principles as they relate to joint and muscle function in effective skiing movements as well as the interaction between the skier and equipment.

COURSE OBJECTIVES: After completing this course, the ski teacher will be able to

- identify actions taken by a skier to control and guide motion in a variety of conditions and on varying terrain.
- discuss the manipulation of the way the ski/snow and pole/snow reaction forces act on the skier's equipment in a variety of conditions and on varying terrain.
- examine effective skiing movements and interaction between skier and equipment in a variety of conditions and on differing terrain.
- introduce alternative movement progressions and change emphasis on selected movement patterns for a variety of conditions and on differing terrain.
- relate different ski characteristics to optimal performance in a variety of conditions and on differing terrain.

COURSE OUTLINE

Introduction to the Science of Skiing

A. Program content
   a. Personnel introduction
   b. Course overview and goals
   c. Activities for the course

Course Outline for the Science of Skiing

A. Integration of the equipment system across conditions and terrain
An appropriate combination of equipment and movements optimize skier performance.
   a. Types of skis/boots/poles commonly used for condition or terrain
   b. Construction
      http://science.discovery.com/videos/how-its-made-alpine-skis.html
   c. Performance characteristics
      i. Groomed
      ii. Ice
      iii. Bumps
      iv. Powder

B. Effective and skilled movements across conditions and terrain

Base the mechanics of teaching on fundamentals of efficient movements and adaptability to the situation, conditions, and terrain.

Guidance of the body along the desired path and maintaining dynamic balance depend on how the forces acting on the skis are transmitted through the body. By determining how the skis act on the snow we can guide the body along the desired path.

Think of skiing a particular condition in general terms; running a race, skiing the zipper line, challenging a steep powder run. As ski teachers, we decide what a successful outcome will be, what movements will support that task, and what movements will counter the disturbances that tend to disrupt successful execution. (Juris Vagners, *A Ski Instructor's Guide to the Physics and Mechanics of Skiing)*

When an outcome has been determined, blend the four core movements to produce the desired outcome. To find the best blend, the ski teacher must consider snow conditions, equipment, speed, terrain, and the physical characteristics of the skier. By blending the skills in different combinations, one can produce very different performance outcomes.

a. Balance

PSIA-AASI Movement Matrix: see Skills Concept Balance: Main Introduction

http://www.thesnowpros.org/index.php/PSIA-AASI/video-gallery/turn-balancee - all
http://www.thesnowpros.org/index.php/PSIA-AASI/video-gallery/balance2 - groomed
http://www.thesnowpros.org/index.php/PSIA-AASI/video-gallery/balance - steeps
http://www.thesnowpros.org/index.php/PSIA-AASI/video-gallery/skiing-the-bumps
http://www.thesnowpros.org/index.php/PSIA-AASI/video-gallery/alpine-ice

Powder: Balancing Movements
Stance: A narrow stance simulates a single platform which allows the skier to balance against the snow. **Weight Distribution**: Both legs flex and extend together to keep the skis more evenly weighted and working as a single platform. **Fore/Aft**: Maintain a neutral fore/aft stance with the center of mass balanced between the arch and the heel. **Lateral**: A moderate range of lateral movements helps the skier balance against the compacted snow.
BALANCE DRILLS/POWDER: **Shallow Turns; Straight Run**

Carving: Balancing Movements
Stance: A wider stance facilitates a greater lateral range of motion as balance and weight are directed to the outside ski. **Large Range**: While moving through the turn, the outside leg is extending as the inside leg is flexing. This allows the center of mass to move to the inside of the turn while also aligning balance with the outside ski. **Fore/Aft:** The range of balance will move between the ball of the foot to the arch to the heel so that the skis will slice from tip to tail. **Lateral**: Strong lateral movements are accompanied by a leveling of the shoulders and hips. This creates angles as the turn develops, allowing the skier to align balance with the outside ski.
BALANCE DRILLS/CARVING: **Pole Drag; Pyramid of Power; Traverse Moderate Terrain**

Bumps: Balancing Movements
Stance: A narrow stance simulates balance over a single platform and allows both skis to pass through the same spot of terrain at the same time. **Weight Distribution**: Both legs flex and extend through a large range of motion to keep the skis working together. **Fore/Aft**: Maintain a neutral fore/aft stance with the center of mass balanced between the ball of the foot and the heel. **Lateral**: An upright upper body allows a greater overall range of motion of the legs; the strongest lateral angles are created in the lower legs.
BALANCE DRILLS/BUMPS: **Gas Pedal; Ski In Contact; Crab Hop**

Ice: Balancing Movements
Stance: A hip-width stance creates options for proper alignment over the outside ski and/or for engaging both edges. **Lateral**: The rate of travel and the quality of edge engagement on ice determine how fast and how far one can move laterally inside the turn. Independent flexion and extension of the legs facilitates lateral and forward movements. **Fore/Aft**: Maintain a neutral fore/aft stance with the center of mass balanced between the ball of the foot and the heel. **Level Shoulders**: Lateral movements are accompanied by a leveling of the shoulders and hips. This creates angles as the turn develops, allowing the skier to align balance with the outside ski.
BALANCE DRILLS/ICE: **One-ski skiing, Hockey Stops, Sideslips**

b. Rotary Movements

PSIA-AASI Movement Matrix: see Skills Concept Rotary Movements: Main Introduction

Powder: Rotary Movements
Steer: Simultaneous steering of the legs helps shape the turn. **Counter Rotation**: Upper body or counter-rotary movements may be necessary to aid leg steering. **Deflection**: Tipping of the skis, combined with rotational movements of the legs, produce the desired amount of deflection against the skis. **Pole Action:** Rhythmic pole action is used to assist initiation and provide timing and direction for movement through the turn.
ROTARY MOVEMENT DRILLS/POWDER: **No Poles; Patience Turns; Walk Poles**

Carving: Rotary Movements
Steer: Subtle, simultaneous leg steering and a disciplined upper body create a slightly countered relationship as the turn develops. **Input**: Subtle, accurate leg steering helps adjust the turn shape as dictated by the carving skis. Rotary input originates from the upper legs. **Increase Edge**: Rotary input from the upper legs will help increase or decrease edge angle and will help manipulate turn shape while carving.
ROTARY MOVEMENT DRILLS/CARVING: **500 Steps; Corridor Step Turns**

Bumps: Rotary Movements
Steer Legs: Both skis need to be directed to the same place at the same time. **Rate**: The rate at which the skis are steered, guided, or pivoted must match the size and shape of the bump, and may range from a quick pivot to a precise guiding action. **Match Terrain:** Focus on turning the feet and legs to match the shape of the bumps; continue to steer and guide whether flexing or extending. **Pole Use**: A blocking pole plant is used to stabilize the upper body and enhance core stability for more precise movements into the new turn.
ROTARY MOVEMENT DRILLS/BUMPS: **Gorilla Turns; Linked Hockey Stops; Pivot Slips in a Corridor**

Ice: Rotary Movements
Input: Subtle, simultaneous, and accurate leg rotation and a disciplined upper body create upper and lower body separation as the turn develops. **Steer**: Minimal leg rotation in the initiation phase of the turn will prevent skidding (displacement) of the tails. **Leg Rotation**: Subtle and accurate leg rotation through the shaping phase of the turn needs to match the degree of edge hold and the shape and size of the turn.
ROTARY MOVEMENT DRILLS/ICE: **Pivot slips; Pivot Checks; Double Turns; Arced Garland Turns**

c. Edge Control Movements

PSIA-AASI Movement Matrix: see Skills Concept Edging: Main Introduction

Powder: Edge Control Movements
Conditions: Snow conditions will influence whether edge release happens while flexing the legs or extending them. **Edge Angle**: The degree of tipping of the skis is dependent on the amount of deflection desired against the bases of the skis. **Boot Contact:** Maintaining forward and lateral contact with the boot cuffs minimizes fore-aft changes in your balance caused by variable snow. **Control:** Tipping movements expose the base of the skis to the snow, where deflection contributes to turn shape.
EDGING DRILLS/POWDER: **Half and Half, Retraction Turns, Turn Against Resistance**

Carving: Edge Control Movements
Flex: Lengthening the outside leg while shortening the inside leg allows the center of mass to move inside the turn so the skier can tip the skis onto their edges. **Leg Release:** Edge release and re-engagement is a result of tipping the skis. The degree in which one independently flexes and extends the legs is a factor in establishing edge angle, while maintaining structural alignment. **Lateral:** Early, forward movement through the boot cuffs creates positive, early engagements of the tips, drawing the skis into the shaping phase of the turn. **Timing:** Emphasis on the direction and timing of the pole swing directs movement into the new turn.

EDGING DRILLS/CARVING: **Crab Hops; Outriggers; Railroad Turns**

Bumps: Edge Control Movements
Pole Plant: A blocking pole plant stabilizes the upper body and aids tipping movements of the legs. **Edge Angle**: Edge angle will vary depending on the placement of the skis on the bump or in the trough. **Terrain Timing**: Timing of the edge release and edge engagement is dependent upon the size of the bump, the size and shape of the turn, and the choice of line. **Tipping**: The lower legs generate edging movements and help maintain ski-snow contact.
EDGING DRILLS/BUMPS: Air Carve; Turn shaping in bumps

Ice: Edge Control Movements
Flex/Extend: Lengthening (extending) the outside leg while shortening (flexing) the inside leg allows the center of mass to move forward and inside the turn so the skier can tip the skis on edge. **Pole Use**: An accurate pole swing in the direction of travel, synchronized with independently changing leg lengths, contributes to a smooth edge release and re-engagement. **Lateral**: Early and precise forward and lateral movements through the boot cuffs creates positive and early engagement of the tips, moving the center of mass into the turn and drawing the skis into and through the shaping phase of the turn. **Edge Angle:** Progressively increase the edge angle of the skis through the initiation and shaping phases of the turn. As you begin to decrease the edge angle in the finishing phase of the turn, maintain body alignment with the skis laterally and fore/aft.
EDGING DRILLS/ICE: **Railroad Tracks; Dynamic Wedge Turns; Check Turns**

d. Pressure Control Movements

PSIA-AASI Movement Matrix: see Skills Concept Pressure: Main Introduction

Powder: Pressure Control Movements
Flex/Extend: Both legs flex and extend together to resist forces created by snow and pitch. **Maintain Pressure:** Flexion and extension adjustments are used to maintain lateral balance over both feet creating a single platform, centered

fore and aft.

PRESSURE DRILLS/POWDER: **Retraction Turns; Dolphin Turns; Progressive Bounce**

Carving: Pressure Control Movements

Strength: The skier should maintain strength in the length of the outside leg through the highest loading portion of the turn, unless yielding to the influence of terrain, snow conditions, or releasing the turn.

Leg Movements: To manage the variations in pressure through the turn, the legs must flex and extend independently. Extending will increase pressure, while flexing will reduce or release pressure.
Directed: Pressure is more evenly distributed at slower speeds and on shallower terrain; the majority of the pressure is directed to the outside ski at higher speeds, on steeper terrain, and in deeper turn shapes.

Lateral Redistribution: Foot to foot re-distribution of pressure during the turn transition can range from gradual to abrupt, but the movements should remain controlled and accurately directed.

PRESSURE DRILLS/CARVING: **Skating; Step Turns**

Bumps: Pressure Control Movements

Simultaneous Flex/Extend: Simultaneous flexion and extension of both legs creates minimal lateral movement, maintains balance over the base of support, and is used to manage pressure and maintain ski-snow contact.

Range: The range of flexion and extension needs to match the size of the bump to maintain ski-snow contact. Pressure can be influenced by the placement of the skis on the bump or in the trough.
Redistribution: Pressure re-distribution is a result of foot, ankle, knee, and hip movements.
Boot Contact: Forward contact with the boot cuffs helps maintain tip pressure. Snow contact along the length of the skis can be influenced by moving the feet under the body or moving the body over the feet.

PRESSURE DRILLS/BUMPS: **Falling Leaf; Dolphin Turns; Retraction Turns**

Ice: Pressure Control Movements

Tipping: Accurate fore/aft movements and accurate tipping (lateral) movements will allow you to distribute pressure along the length of the skis and from foot to foot dependent upon the quality of the snow surface. Maintaining the length of the outside leg, combined with controlled flexion of the inside leg, helps manage pressure throughout the turn.

Independent Legs: Depending on the desired turn type and shape and the quality of the snow surface, the application of pressure will be quick or will occur progressively throughout the turn. **Directed**: Pressure is more evenly distributed foot to foot at slower speeds and on shallower terrain. More pressure is directed to the outside ski at higher speeds, on steeper terrain, and in deeper turn shapes. **Lateral Redistribution:** Lateral re-distribution of pressure during the turn transition can range from gradual to abrupt. Movements should be intentional and accurately directed to stay aligned with the skis through the transition and into the new turn.
PRESSURE DRILLS/ICE: **1000 steps; Up and Over Turns; White Pass Turns**

Summary

The guidelines suggested in the PSIA Alpine Movement Matrix are intended to help the instructor focus on specific movements across differing conditions and terrain and to make the connections between desired muscle activity and a successful outcome for the student. These guidelines help ski teachers understand the application of the fundamental skills to a variety of situations. These guidelines recognize how anatomy, physiology, and physics influence human motion on skis.

In considering the conditions of the day, the issues are, “What is the purpose of the turns?” and “What are the means available of attaining that purpose?” (Vagners, 1995)

A. Questions and answers

STUDY QUESTIONS

Discuss stance and balance issues for a skier with regard to making a correct or incorrect ski selection for powder, bumps, carving, and ice.

Develop examples of appropriate and inappropriate equipment systems for a variety of conditions.

Discuss ski performance for various combinations of skier body types and snow conditions.

Discuss the effect of sidecut on turn shapes and efficiency of turning in a variety of conditions and on differing terrain.

Downhill Skis



It's that time of year again. Time to head off to the mountain for some quality powder time. But don't think that you have to be a skier of Olympic standards to have fun on the slopes--skiing is an awesome plan for the whole family and can be fun if you have the right attitude, equipment and conditions.

Moreover, choosing equipment can be daunting if it's your first time making this type of purchase. Here is everything you need to know about skis to start your season off on the right foot. There are lots of different skis for different kinds of skiers. Also, make sure that you don't get honking huge skis like the old days. These days, new ski technology makes shorter skis more stable and faster, so where you might have skied on a 193cm ski before, you might think about skiing on a 165 - 170cm ski today.

Whatever you do, do not show up on the mountain in white rear buckle Lange boots from 1985 with a pair of 205cm skis from 1990. If you do that, topped off with a neon one-sie you are sure to be ridiculed by all those around you.

Which Skis are Right for You?

Factor #1: Gender and Age

The most basic considerations to start with are your gender and age. Males and females need different types of skis since their bodies are built differently. Women's skis are specifically designed to be more flexible and lighter to compensate for the way their body distributes weight. Children will need basic kid's recreational skis to match their height and weight (allowing some room for future growth), which is discussed in the following section.

- **Women's Skis**
  - Since women have a lower center of mass than men, they have different needs in terms of skis.
  - Because of their center of mass, women lean back more, thus women's skis place them further forward.
  - Since women are lighter, their skis need to be lighter and have more flex.

Factor #2: Height, Weight, and Ski Length

Time for the next step: determining the proper ski length for your weight and height. The rough guide recommendations below assume that your height and weight are proportionate. Keep in mind that everyone is different and that some slight adjustments may need to be made according to things such as your skill level, aggressiveness, and which ski type you choose.

- **Skill Level**
  - Beginner skiers need skis an inch or two shorter than their own body.
  - Intermediate skiers should choose something very close to their height or slightly taller if they are advanced intermediates.
  - Advanced skiers and experts should add length to their skis; 5 cm and 10 cm, respectively.

- **Skiing Style**
  - For speed, choose a slightly longer ski.
  - The more powder you ski in and the more "off-piste" adventures you go on, the longer you will want your skis to be so that they can help you "float". Add from 5 to 10 cm for freeride skis and 5 to 20 cm for big mountain skis.
  - Slalom skis are usually meant to be short. Subtract 10 to 15 cm from your suggested ski length.

- **Ski Type**
  - Recreational skis should be just tall enough to hit between the skier's chin and eyes.
  - All-mountain skis should fall somewhere between the skier's nose and forehead.
  - Free-ride skis should be about up to your eyes or taller.
  - Freestyle skis fall at your nose level.
  - Back-country skis are the biggest and widest you can get in accordance with your skiing ability.

Factor #3: Skill Level

There is no sense in buying skis that are not adequate for your skiing level. It is true though that if you get skis with a little more oomph to them than you need, it will leave room to improve. However, skis that are designed with the advanced racer in mind will not help a beginner skier learn the basics. With the guide below, see which category best matches you skiing ability to determine which type of ski you will need.

- **Recreational: Greens and Blues**
  - You have never skied before.
  - You have gone on the bunny hill and have learned to snow plough.
  - You can turn and stop and have tried your skills on some green runs.
  - You have tried some blue runs and mastered them as well as stopping and turning with ease.

- **Advanced: Reds, Moguls, Maybe Blacks**
  - You are up to red runs.
  - You don't need to snow plow anymore and you are practicing parallel technique.
  - You are trying out black runs and moguls.
  - Ice and steep slopes combined are scary but you still manage on them.

- **Expert: Blacks, Double Diamonds, and Off-Piste Skiing**
  - Double black diamonds are a piece of cake.
  - You venture off the piste.
  - You may have raced or taught before.

Factor #4: Surface Type

Although skis will basically work on all surfaces, many skis are designed to work perfectly on a specific surface. So look for the best skis for the conditions you usually ski. Skis designed today are Pure Powder, Groomed Powder, and the catch-all Packed Powder Conditions. These are the conditions at most resorts. In general, the best powder is in the west and the east hopes for the best.

Downhill Ski Types

Recreational	**All Mountain**	**Powder**	**Race**	**New School/Freeride**
A great alternative to rentals. They're most common for new skiers who stick to the piste. They're easy to turn and comfortable in	Offering the performance of a race ski but without the required effort and skill, all-mountain skis are by far the most popular choice	This specialized style is wider, softer and longer than an all-mountain ski, making them float over the snow. Fine for upper-	Race skis are highly specialized tools. Due to their unique attributes they are not a great choice for non-racers since they're destined	Also known as freestyle skis, this type of skiing continues to gain popularity on the slopes. They are designed with aerial tricks in

most conditions, allowing users to focus on their technique.	for today's skiers of all levels.	intermediate and advanced skiers who like powder.	to advanced and experts skiers.	mind, for jumps and halfpipes. For advanced skiers.

Features Explained

After deciding which type of ski best fits your individual needs, it's important to look at some of the features and what the jargon really means.

Sidecut: This is the amount of curve in the ski's hourglass shape when viewed from above. You will hear the terms tip (front edge), waist (center), and tail (rear edge). They are simply describing the width of the ski at these points on the ski. Together, the dimensions of the tip, waist, and tail make up the sidecut. Deep sidecuts offer the skier more stability when carving tight turns, while shallower sidecuts are more suited for carving longer turns.

- For powder, look for a wider "waist".
- For easy carving, look for a narrower "tail" and a wider "tip".

Stiffness: Stiffness is an important factor depending on your ability. Here are general guidelines:

- Soft, wide, straight skis are ideal for beginners because they will slow the skier down.
- Intermediate skiers will want slightly stiffer skis that are narrower at the tail and center so that they can go faster.
- Experts skiers like stiffer skis to help transfer body weight evenly to the ski's tip and tail and for maximum speed.
- Soft-flexing skis are good for mogul skiers.

Camber: Modern skis have adopted this from snowboarding. New skis are shaped in such a way that they do not sit flat on a table. Instead the center bends upward off of the table while the nose and tail points touch the surface.

- This has allowed for much shorter skis, nicknamed "shorties", that have the same performance as longer flat skis.
- A reverse camber, where only the ski's center touches a flat table, is called "rocker "

Construction: The materials used to construct the ski give it strength, density, lightness, and flexibility.

- Ever since the first Norwegian strapped wooden planks to his feet and rocketed down a mountain, skiing has been one of winter's most popular pastimes. No longer comprised primarily of wood, (though they often still have a wooden core,) skis are constructed of various components including glass fiber, Kevlar, Titanium alloy or composite materials.
- A common ski construction method is laminate construction, where layers of material are sandwiched together with glue.
- Torsion box manufactured skis are another common technique. These are built by creating an inner box like structure to transfer the skier's energy to the snow. Popular materials used in this type of manufacturing are wood and fiberglass.

Edge: The outer edges of the ski.

- Usually made of carbon-steel, and located on the outer edge of the ski, which provides grip on hard snow.
- The thinner the edge, the more flexible and responsive the ski.

Base: The surface of the ski in contact with the snow.

- Ski bases are typically constructed with hardened polyurethane.
- High end skis often use additives to increase how fast the skis glide.

Alpine Ski Boots

Ski boots can make or break your skiing experience even more than your skis can. Therefore, there should be as little price compromise as possible when it comes to buying boots because comfort is key. When you spend at least two seasons or more in your boots you will be happy that they fit properly and comfortably, even if you have to spend a few extra bucks on a good pair. Otherwise, skiing can become agonizing rather than thrilling.

Deciphering Boot Types

	
Rear-Entry • Simple, cheap, and comparable to what you will find in a ski rental shop. • Not recommended for anyone who really wants to get into skiing, although they will suffice for a beginner who wants to learn the basics before upgrading to better equipment. • Expect that you will outgrow their basic design once you have learned the essentials of skiing.	**Front-Entry** • Also know as overlap boots, these are the best choice for any enthusiast or pro skier. • They offer superior control and stability with a solid outer shell and a well padded inner lining. • These are the most common boots on the market. • Harder to get on and off that rear-entry boots. • These are also the most expensive boots.

Choosing The Right Boot

Size Chart

Size for ski boots is usually measured in mondopoint size (cm), which comes in full and half sizes. At right is a rough guide to how street shoes correspond to mondo sizing. Keep in mind that this is a *ROUGH* guide. Consider the factors mentioned above, and remember that nothing proves what size is best like trying the boots on yourself.

MONDO	WOMEN'S	MEN'S
23	6.5	5
24	7.5	6
25	8.5	7
26	9.5	8
27	10.5	9
28	11.5	10
29	n/a	11
30	n/a	12

Trying on Boots

When going to try on boots there are a few things to know. First of all, bring the socks you plan to wear while skiing with you -- preferably ski socks, not everyday socks. Go to try boots on later in the day after your feet have swelled a bit. It will give you a better idea of how the boots will fit after skiing an hour or two.

- Toes should be near the front of the boot but not touching.
- Heels should not slip off the boot sole when you flex your knees while in the boots.
- The tightening straps should feel firm but not like they are cutting off your circulation.
- When bending your knees in the boots, take note of the following:
    - **Too hard to flex.** Translation: they are too strong for your weight or ability. You will not have enough control over your skis and you will be unable to turn properly. Go for an easier to flex pair.
    - **Too easy to flex**. Translation: they will not offer enough support for your weight and/or ability level. Avoid this at all costs, as they will cause premature fatigue and may even put you at risk for injury.

- Spending some time in the boots you want to buy will work to your advantage. This allows you to feel any tender or sore spots that boot pressure creates.

Factors Affecting Boot Size

- Women and children need boots specifically made for them. Obviously, children's boots will be smaller. However, since women's bodies are built differently than men's, they need boots that can accommodate the way their weight is balanced.
- Feet swell during aerobic activity. That is why trying boots on at the end of the day is a more realistic way of determining how the boots will fit while you are skiing.
- Socks need to be the right thickness. They cushion your bones and other tender parts of the foot.
- Different foot widths need to be taken into account. That goes both for the toes and heels. Since all manufacturers build their boots differently it's important to try on

several types before making a choice. What may work well for one person, is not necessarily what will work best for you.

- High arches or shallow insteps will all play a role in how a boot will feel on your foot. For some, inserts may make an improvement on the fit and feel of a boot.

About Ski Socks

- When going to a ski shop to try on different boots, be sure to bring along the proper socks that you plan to use while skiing.
- For ski socks, thickest is not necessarily the best.
- Depending on whether or not your feet tend to sweat or freeze, you may need different materials and/or thicknesses.
    - If your feet sweat look for a very breathable sock made of synthetic fibers.
    - Sweaty, perspiring feet can end up freezing after an hour on the slopes.
    - Anything made of cotton will simply trap the moisture and work against keeping your feet warm.
- Socks with silk or cashmere are a very comfortable, lightweight, option, but they are also very pricey and tend to wear very quickly.
- Wool socks are nice and sturdy while providing a good level of warmth.
- Look for combination of materials in socks to get the best pair for your needs.