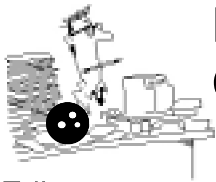

Editor's Corner:

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Well, here it is again guys. Print it out when you desire.

Place selected pages in a binder for your students. Copy selected pages and use in your classes.

In this issue:
Advanced Lane Play:
Matching Up -
The Bowling Ball

October Issue:
Matching Up the Ball to the Lane Conditions

The Coaching Eye

Volume #1 - Issue #3
September 2002

This month I have included an abbreviated version of **Advanced Lane Play: Matching Up - The Bowling Ball.** Distribute copies to your students as you desire.

The Bowling Ball is included this month and **Matching the Ball and the Lane Conditions** will be included next month. Each part of each section (like a chapter) starts on a separate page. This allows you to cover a specific topic, one at a time with your student.

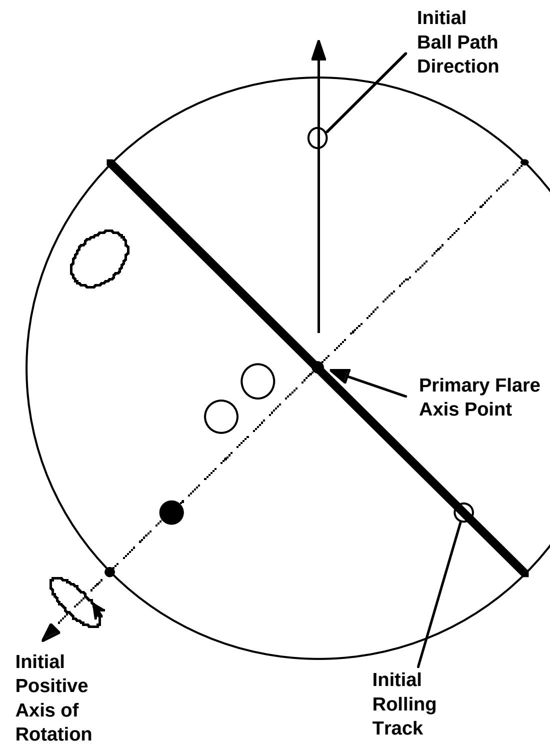
If you think of other topics pertaining to **Matching Up** and want to let other coaches know about them, please write it up, send it to me and I will review it and publish it with your name as the author. Send as a Microsoft Word file as an attachment to an e-mail to me. And, if you have other topics or ideas that would be of use to other coaches, please send them to me. Share those ideas and we will all grow as better coaches.

Note that each issue stands on it's own as a publication. Hence, some topics appear in multiple issues. (A left handed bowler version of Advanced Lane Play and back issues are available - free - upon request. Just e-mail us the request).

Each issue is designed to be a fund raising booklet for your local Youth Bowling Program. Excluding the cover page, make some clean copies and let the Youth Director sell them at the control desk or in the pro shop to raise money for the youth bowling program.

This issue is about 69 pages in length. Check your printer paper before printing it out. Please read it yourself before giving it to your students.

The Bowling Ball



by
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From the Bowling Ball's Point of View

Okay, he finally released me and I'm ready to do my thing. My bowler has placed some sideways torque and some forward torque on me so I'm spinning about both those axes.

Now if I can just get gravity to let me down to the lane surface I can begin to roll.

Thud!

Ouch, that smarted! Ha Ha Ha, I left a little indention in the lane surface too, I bet the bowling center won't like that.

Whoa! I'm slipping, I'm slipping! I'm in that nasty ole oil now and it's really hard to get any traction in this area. Heh, I can't get enough traction to begin breaking toward the pocket!

I don't like the way my bowler has rotated me when he released me. He knows I like to roll over the PIN on the ball, why does he always roll me so that I'm having to re-orientate myself so that I can roll over my PIN?

Talk about dumb. My bowler does the same dumb thing every time. He releases me so that I'm spinning forward and sideways at the same time. Wow, part of me says go down the lane and another part of me says go across the lane. I wish he would make up his little mind.

But you know, those spins that he gave me will help me start to flare and get to that "over the PIN" orientation that I like. Okay, even though I'm still in the heavy frontend oil, I'm gonna start flaring. Flare baby flare! I really want to get to the "over the PIN" rolling orientation.

The sideways rotation and the flaring to expose new fresh surface that hasn't touched the oil will help me break toward the pocket but all of this frontend oil is just too much; I'm not even breaking at all. I'm just sliding down the lane spinning and flaring and not really accomplishing much at all. Heh, I am doing one really important thing though, I'm saving a lot of my energy for the impact with that gang of pins at the end of the lane.

If I can ever stop this slipping, I'm going to change this dumb direction he's initially placed me into and start breaking toward my arch enemies, George and Ralph, the "one" and "three" pins. And, I know just where to hit George to make it really hurt bad. Ralph I'll take care of as soon as I've finished with George.

I want to destroy those guys. Every time I miss the head pin, George makes fun of me. He wiggles his little certification label and says that nah nah nah nah pooh pooh thing. Boy I hate it when he does that.

I know that I will have the best chance of getting through the entire gang of pins if I am rolling directly over the PIN on my surface.

I want to roll over the PIN on the ball. I like to roll over the PIN. When I roll over the PIN, I've got the most rotational inertia in effect; that's where I want to roll. If I can just get a hold of a little friction where I'm making contact with the surface, I can begin to break toward the pocket. I'm really dissatisfied with the direction I'm headed now and how I'm spinning now.

Hooray! I can see the end of the oil coming up! Boy am I ready. When I hit that dry area, I'm gonna get some traction and I'm gonna break like a son-of-a-ball so that I can get to where I want to be down at the end of the lane, at the pocket. If I don't start breaking pretty soon, I'll never be able to get back to the pocket. Here goes. Break baby break and flare baby flare!

If I can break just enough and flare just enough, I will smack George at just the right impact location just at the instant I am rolling directly over the PIN on my surface.

All right, I'm turning! Here comes the pocket, just a little further. Come on, flare baby flare! I've got to get enough angle of attack into the pocket to knock down the 5 pin after I get through with the head pin and the 3 pin. Flare flare flare! Turn turn turn!

Okay, that's all I can flare! But it's okay, I'm just about to impact the right side of the head pin. I'm at a great angle of attack with enough energy still left so that I can make it through all the impacts that are about to happen.

I'm gonna stop flaring now. I've made it to where I want to be; I'm rotating with the PIN on my surface directly on my rolling track. I want to concentrate all of my energy by going one direction and get maximum traction in that direction.

Here comes the head pin. I'm going to try to knock it to the left at the 30 degree pin line angle to the left so that it knocks down the 2-4-7 pins at that same angle. If I can do this right and hit the head pin at the 30 degree pin line angle location, the head pin will deflect into the 2 pin at that 30 degree pin line angle.

The deflected 2 pin will impact the 4 pin at that same angle and then will knock down the 7 pin at that same angle. This ain't gonna be easy but I really need to try to do it this way. I really want it bad. Here goes . . .

Bang!

All right! Asta lavista George! Perfect impact angle and location! Those 2-4-7 pin dudes will be down before I can blink a finger hole.

That head pin impact took a lot of my energy away but I'm still rolling pretty fast and I still have a lot of energy left. I gave up that energy for a good cause though. The 1-2-4-7 left fence row is down.

And, I got a perfect deflection from that head pin impact. I've deflected just enough to be able to hit the 3 pin (Ralph) at it's 30 degree pin line angle to the right so the 3-6-10 pins can be knocked down at that same angle.

I can do this, I know I can do this. When I do this, I can destroy that arch enemy of mine, the 10 pin. I'll impact the 3 pin now at the correct impact angle location; the 3 pin will deflect into the 6 pin at that same 30 degree pin line angle and then knock down the 10 pin. All right, I know what I need to do! Here goes . . .

Here it comes.

Bang!

Perfect impact angle and location! There goes the fence row on the right side! As both finger holes clearly see the arch enemy, the 10 pin, being crushed by the 6 pin. All right, the 10 pin is down, the 10 pin is down , nah nah nah nah nah nah, the 10 pin is down.

Man, that impact took more energy away.

Okay, I've deflected to the left from that 3 pin impact. Is it going to be enough to impact the 5 pin at that 30 degree pin line angle to the left? It looks like it is. I'm going to try. I've got to try. It's going to be close. . .

Bang!

All right! There goes the 5 pin to the left at that 30 degree angle to the left toward the 8 pin. So much for those guys!

Rats! I've really slowed down. I've got hardly any energy left. I've deflected to the right toward the 9 pin. Is it enough?

It looks like it is. It's going to be close. Here it comes. .

Bang!

Good-bye 9 pin, hello pit, here I come.

Okay, I've done all I can do, let me take one last look out my finger holes to check the pin deck area for the damage I've done.
-
-
-
All the pins are gone, the pin deck is again quiet and peaceful.
-
-
I've done my job well. Deep down inside my weight block I feel really good.

And, this was fun. I think I'll do it 11 more times this game.

Heh! You pins up there in the pin setter machine,

I'll be back!

Bowling Terminology Definitions

Arc Point - The transition point where the ball changes it's rolling characteristics from sliding with little or no curve to the beginning of a pronounced curve.

Axis Balance - The PIN of the bowling ball is positioned on the bowler's axis point with respect to the initial rolling track of the ball.

Axis Drilling
The bowling ball is drilled so that the initial axis of rotation is on or very close to the PIN of the weight block. Since the ball starts out at or very near one of the two stable rotational modes, the ball has a very stable and very smooth arcing rolling path.

Positive Axis of Rotation - The center of the bowling ball opposite to the bowler's initial rolling track on the ball on the same side as the gripping holes. This is also called the Positive Axis Point (PAP).

Axis Point - The point on the surface of the ball at the end of the Positive Axis of Rotation.

Backend - The rear part of the lane surface, usually categorized as the part of the lane where little or no lane conditioner has been applied. Depending on the bowling center, the backend can be the last 15 to 25 feet of the lane surface.

Backend Potential - This is a parameter that is sometimes used to compare the amounts of reaction on a drier backend bowling lane surface for bowling balls of a single manufacturer. Note that the backend potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Balance Hole - An extra hole positioned so as to statically balance and finalize the reaction characteristics of the ball. ABC limits the size of a balance hole to diameter of less than 1 1/4".

Ball Rolling Track - The circular region on a bowler's bowling ball where it makes contact with the lane surface. The initial rolling track is usually the most visible because it is usually the wettest.

Break - The movement of the bowling ball laterally across the lane surface.

Center of Gravity (CG) - The location on the surface of the bowling ball where gravity acts straight down from the center of all of the weight of the ball. Manufacturers float a newly manufactured bowling ball on a cushion of air. Once the ball stops moving, the very center of the bottom of the ball is marked as the Center of Gravity (CG).

Core - The inner portion of a three (or more) piece bowling ball consisting of lighter weight filler material just between the cover stock and a heavier and very hard center material.

Coverstock - The outside material of a bowling ball. It can be as thin as about 1/4" to 1 1/2" thick and be made of various materials such as rubber, polyester, urethane and some exotic new reactive or composite materials.

Differential of Radius of Gyration - Radius of Gyration is measured with respect to the “Z” axis which is defined as the direction the PIN points outward from the surface of the ball from the center of the ball. The two other directions are perpendicular to that direction and the Radius of Gyration for those two axes can also be measured. The difference between the Radius of Gyration measured at any two of the three axes is defined as the Differential Radius of Gyration. (The largest is listed as the DRG).

Dynamic Balance - Drilling the bowling ball in such a position as to cause a specific ball reaction during the rolling path of the ball.

Dull Surface - A bowling ball surface that has not been polished so as to allow the ball to exhibit it’s porosity characteristics. A bowling ball that has been sanded at the factory with a specific lower grit numbered sandpaper leaves a dull finish on the surface of the ball. Using a ball spinner and the appropriate sandpaper, the surface dullness can be adjusted to fit the desire of the bowler.

Final Rolling Track (FRT)
The final rolling track on the ball surface. It is usually associated with the desired “over the PIN” orientation after flaring is completed.

Flare - A measure of how much the track changes position during the roll of the ball. It is caused by the bowling ball changing it’s axis of rotation during the roll of the ball.

Flaring Potential - This is a parameter that is sometimes used to compare the amounts of track flare for bowling balls of a single manufacturer. The track flare potential is measured in inches, so all of the manufacturer’s can reasonably be compared with each other.

Forward Roll Axis - The axis of rotation for the movement of the ball down the lane surface toward the pin deck. If you hold your right hand out with the palm facing downward and your fingers representing the direction of the top surface of the bowling ball, your thumb represents the axis of rotation of the forward roll of the ball.

Friction - The interaction between the lane surface and the bowling ball surface which causes the ball to slow down as it rolls farther down the lane after leaving the oil conditioned frontend of the lane.

Heads - The front portion of the lane surface, usually about 20 feet. When they say that they are re-oiling the heads, they usually mean that only that first 20 feet or so is being oiled.

Hook Potential - This is a parameter that is sometimes used to compare the amounts of hook for bowling balls of a single manufacturer. Note that the hook potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Initial Rolling Track (IRT)
The initial rolling track on the ball surface. It is usually the wettest track on the ball.

Label Balance - Drilling a bowling ball so that the CG is near the center of the gripping area of the ball.

Length Potential - This is a parameter that is sometimes used to compare the amount of delay a bowling ball can have before arcing. Note that the length potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Leverage Drilling - The bowling ball is drilled so that the maximum instability from the initial rolling track to the final rolling track is attained. The theoretical location for the PIN is 3 3/8th inches from the initial axis of rotation of the ball.

Leverage Line - An imaginary circle on the bowling ball located 3 3/8" from the current positive axis of rotation. When the PIN of the ball is located on the Leverage Line in the upper right quadrant, the greatest potential for the maximum break possible is realized.

Moment of Inertia - It is the resistance to change in angular velocity of the bowling ball. A bowling ball with a low moment of inertia will be easier to spin up to a high rotational velocity. And conversely, a ball with a high moment of inertia will not spin up easily. It's related to the Radius of Gyration (RG) of the ball.

PIN - The point on the surface of a bowling ball that represents the balance point of the symmetrical internal weight block of a bowling ball. It can be thought of as extending from the exact center of a symmetrical weight block. If you were to have the symmetrical weight block by itself, you could turn it over and stand it on the PIN point on the weight block.

Positive Axis Point - It is the center of the hemisphere on the ball defined by the initial rolling track of the ball. With the fingers at the top of the ball and the track to the left of the fingers and thumb, the Positive Axis Point is at the right at the center of that hemisphere. (Same side as the gripping holes).

Preferred Spin Axis - The rolling axis which the bowling ball searches to reach by flaring the rolling track. One preferred spin axis is at the PIN of a symmetrical weight block (spinning the ball about the PIN of the ball). The other two preferred axes are perpendicular to the PIN axis at the center of the ball (the PIN would be right on the rolling track of the ball).

Radius of Gyration - The relationship between the moment of inertia and the mass of a bowling ball. A bowling ball with a higher radius of gyration has it's overall mass shape located further away from the center of the ball. A low radius of gyration ball has most of the mass near the center. A low RG ball is easier to "rev up."

Reactive Resin - A coverstock material which is usually a blend of urethane with different additives. It has the property of reacting violently on the drier backend portion of the lane surface. It has higher friction on a dry surface.

Revolutions (Revs) - The number of times a bowling ball makes a complete rotation about it's axis of rotation as it rolls from the foul line to the head pin.

Rev Rate - The rotational speed of the ball can measured in revolutions per second although it can be stated as revolutions per minute (RPM). And since that's a much higher number and much more impressive, that's the number you will usually see in the literature.

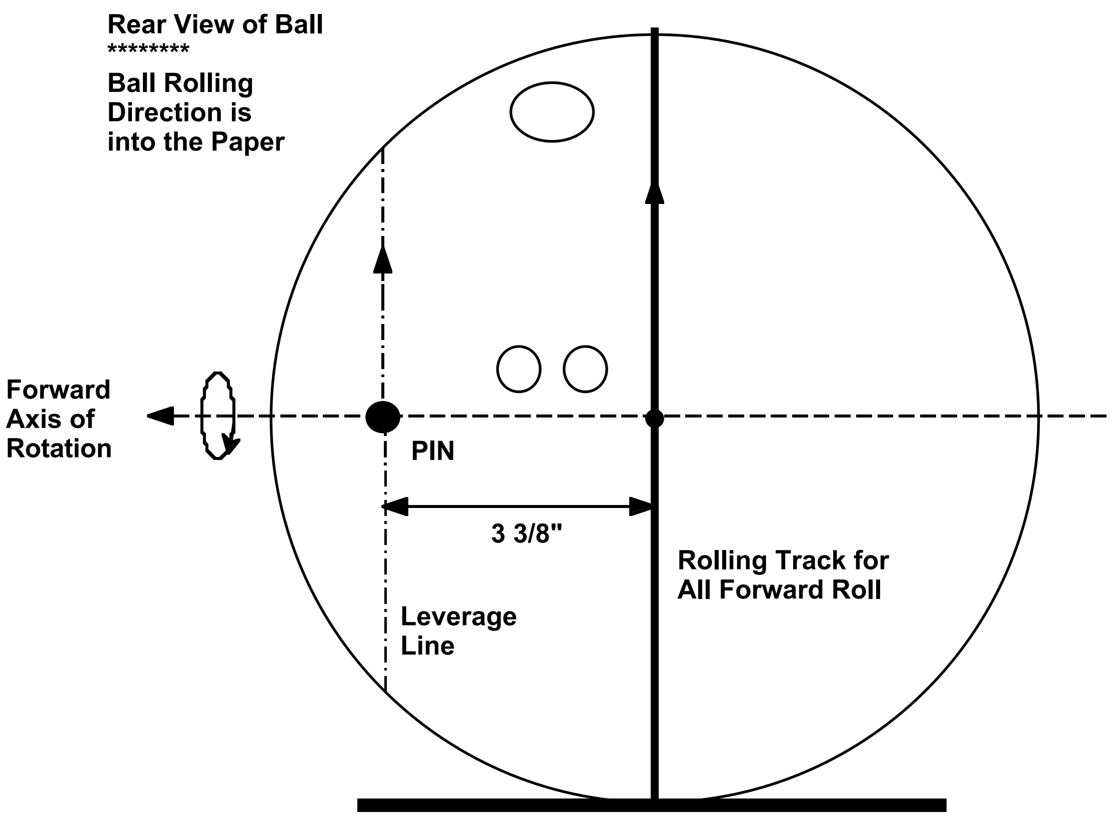
Sideways Roll Axis - The axis of rotation for the movement of the ball across the lane surface. If you hold your hand up and face the palm to the left with your fingers curled, your fingers represent the moving top surface of the ball and your thumb represents the direction of the sideways roll axis pointing to the rear.

Three Piece Construction Bowling Ball - A bowling ball with a dense inner core, a filler material and a dense coverstock.

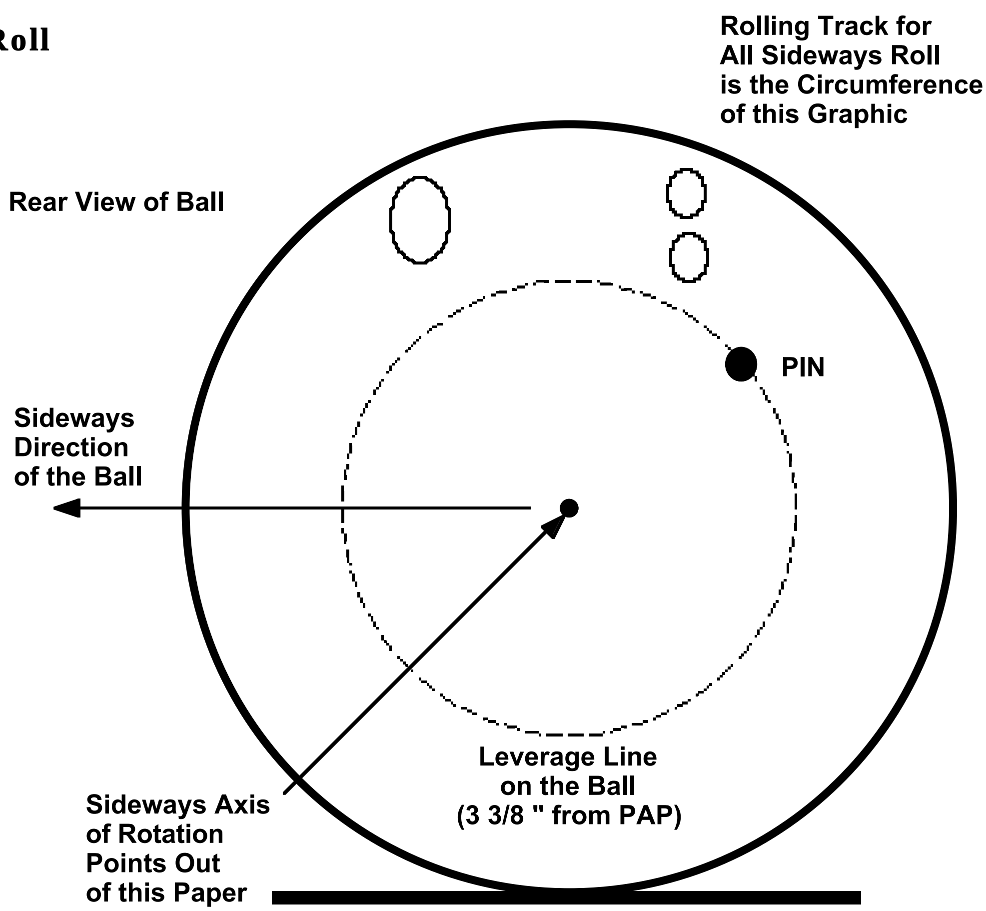
Two Piece Construction Bowling Ball - A bowling ball with an inner weight block and an outer shell.

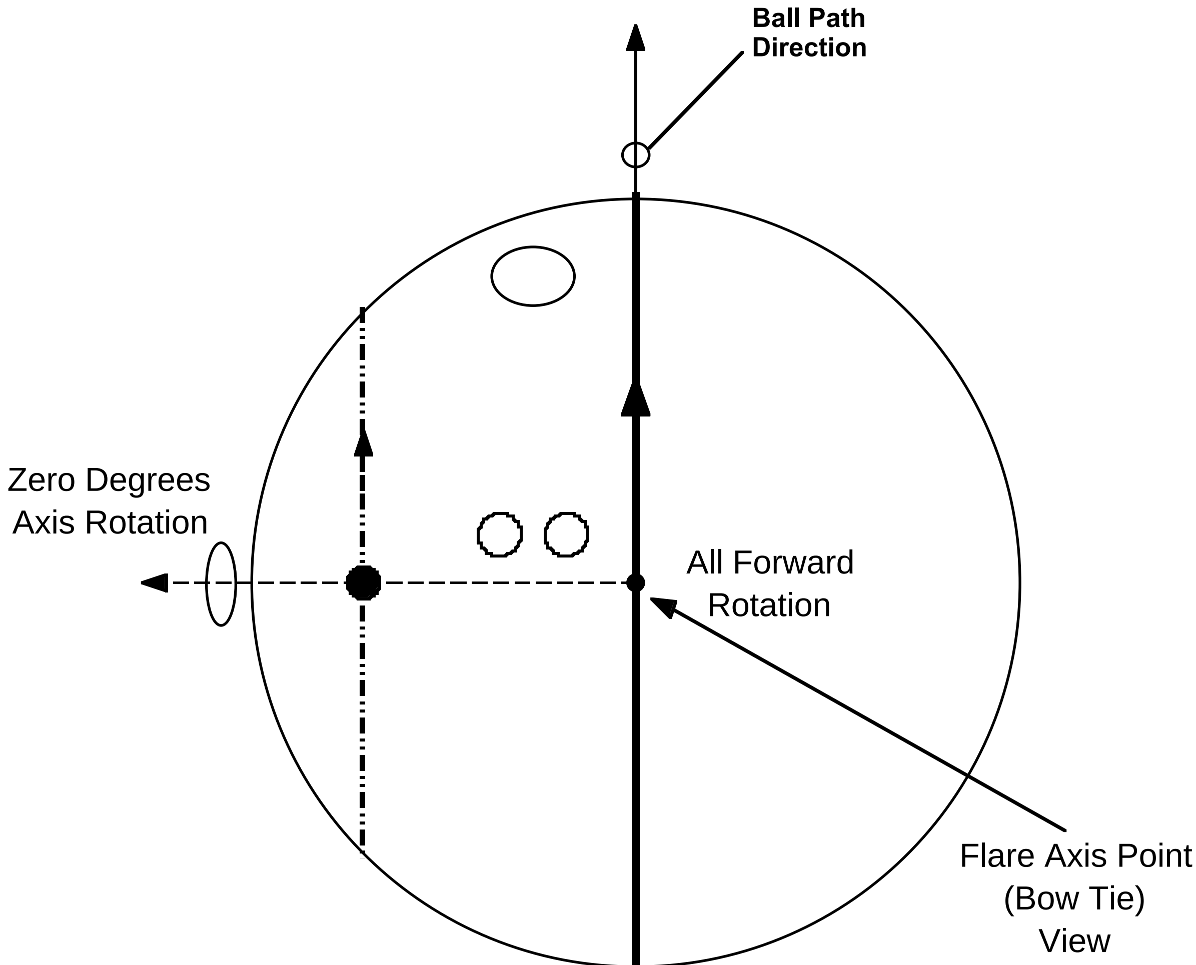
Weight Block - The custom shaped inner mass of a bowling ball.

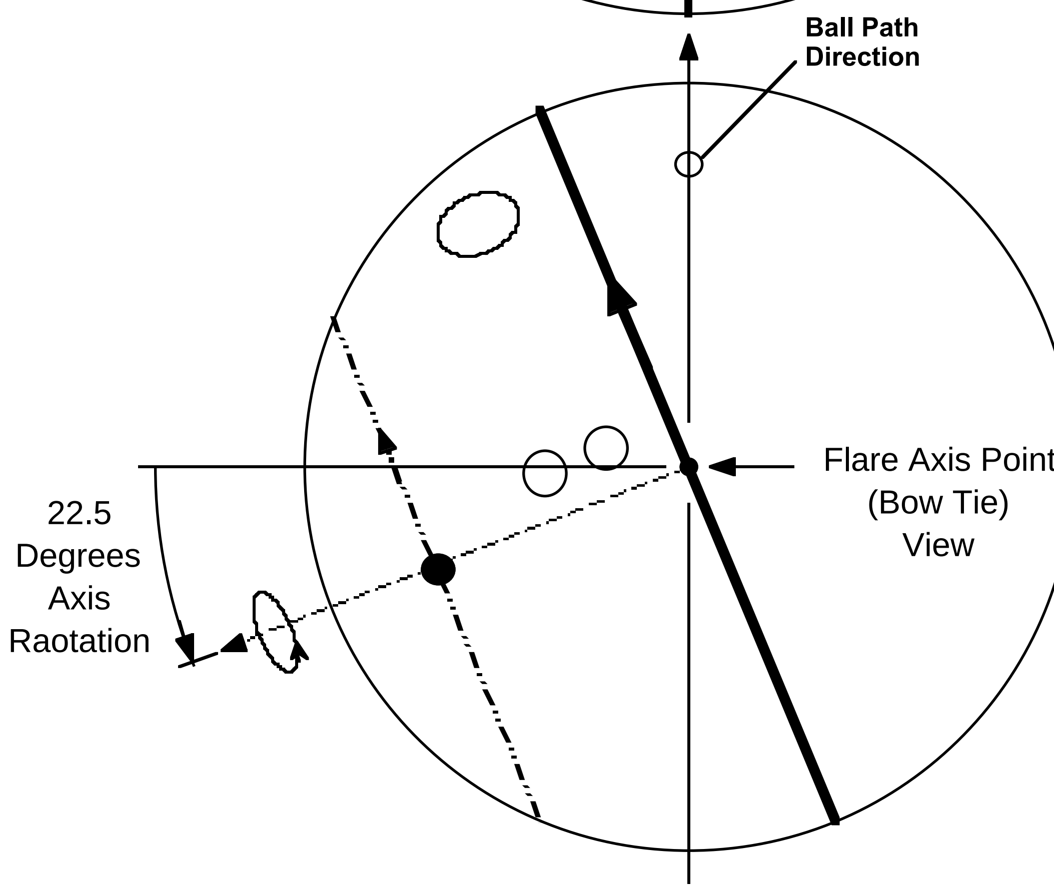
All Forward Roll



All Sideways Roll




Ball Path
Direction
Zero Degrees
Axis Rotation
All Forward
Rotation
Flare Axis Point
(Bow Tie)
View


Ball Path
Direction
Flare Axis Point
(Bow Tie)
View
22.5
Degrees
Axis
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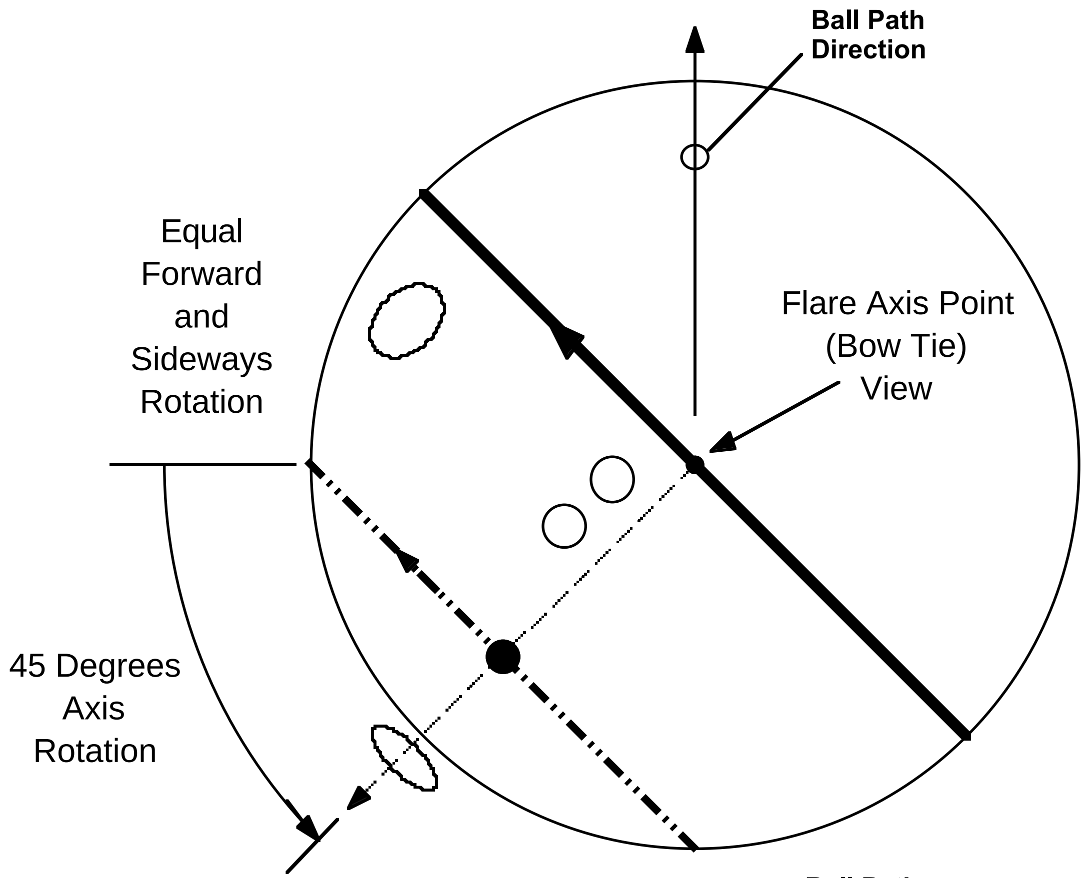
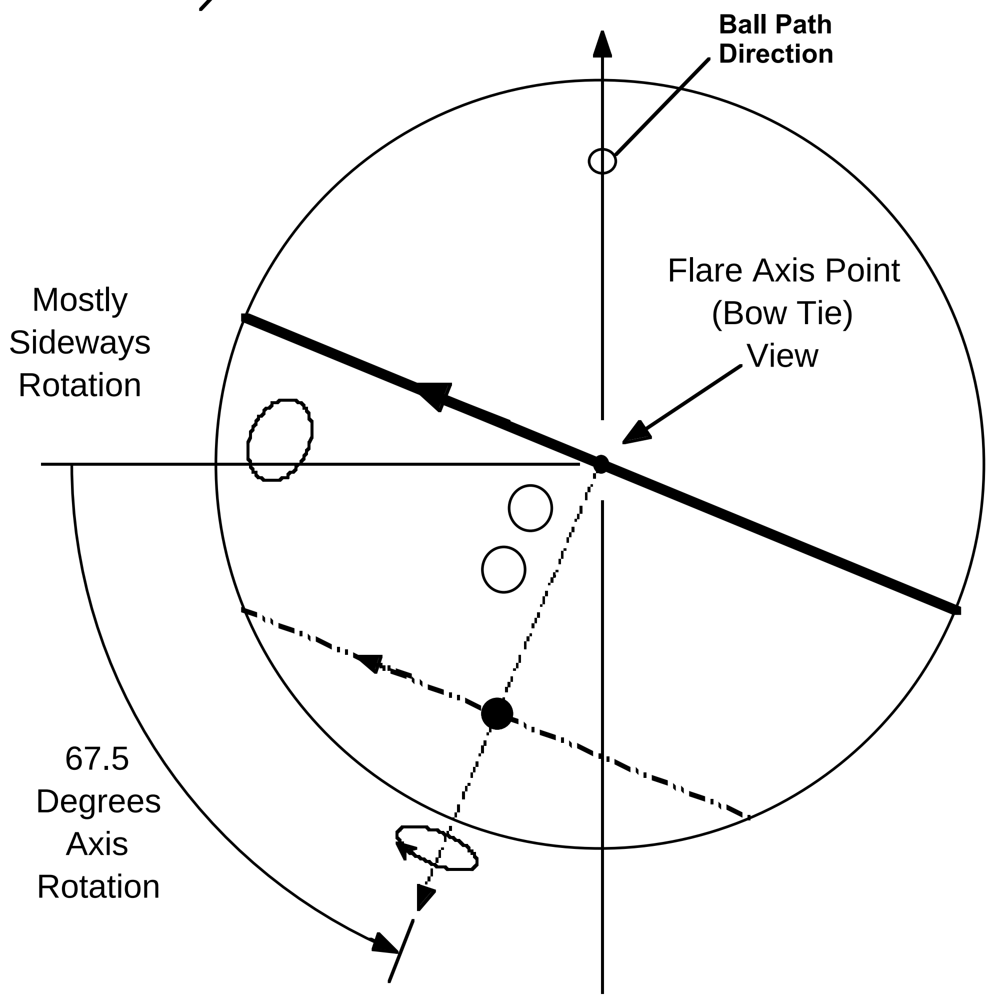
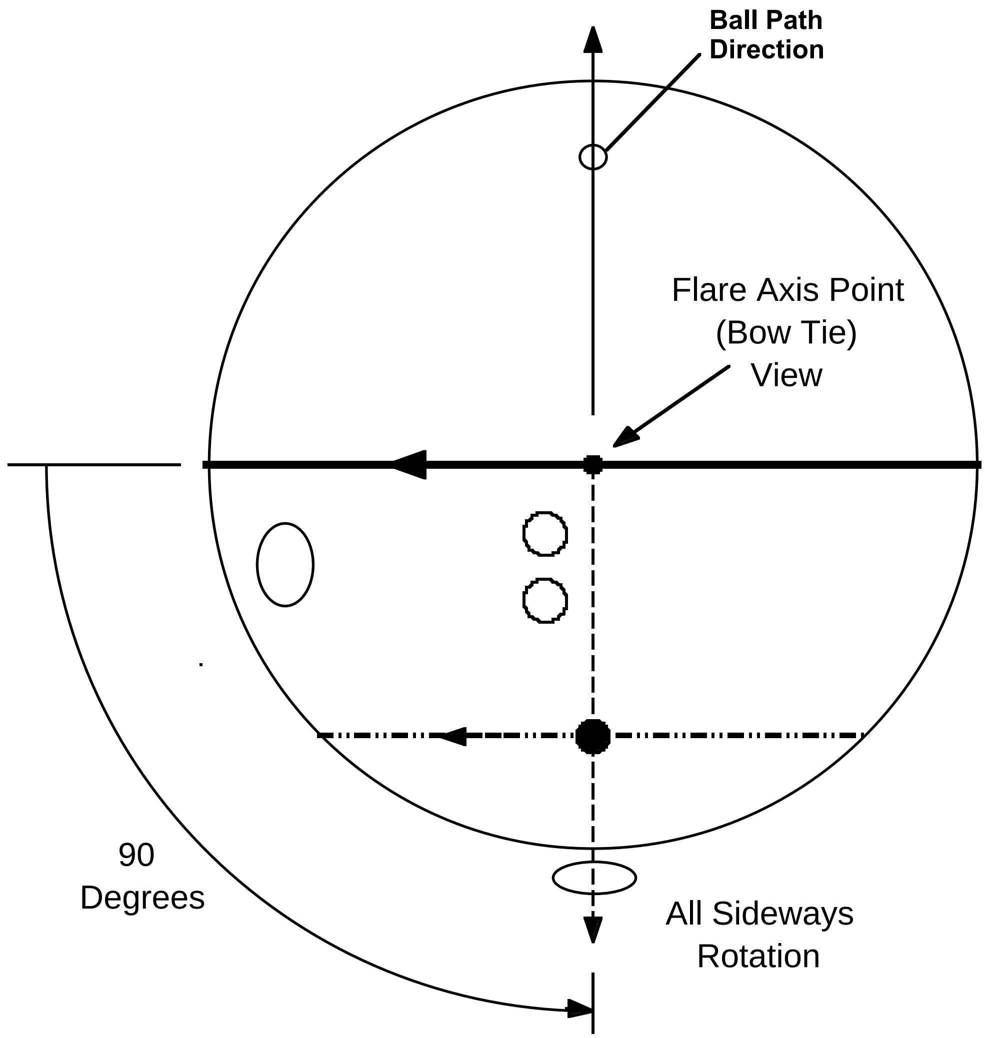
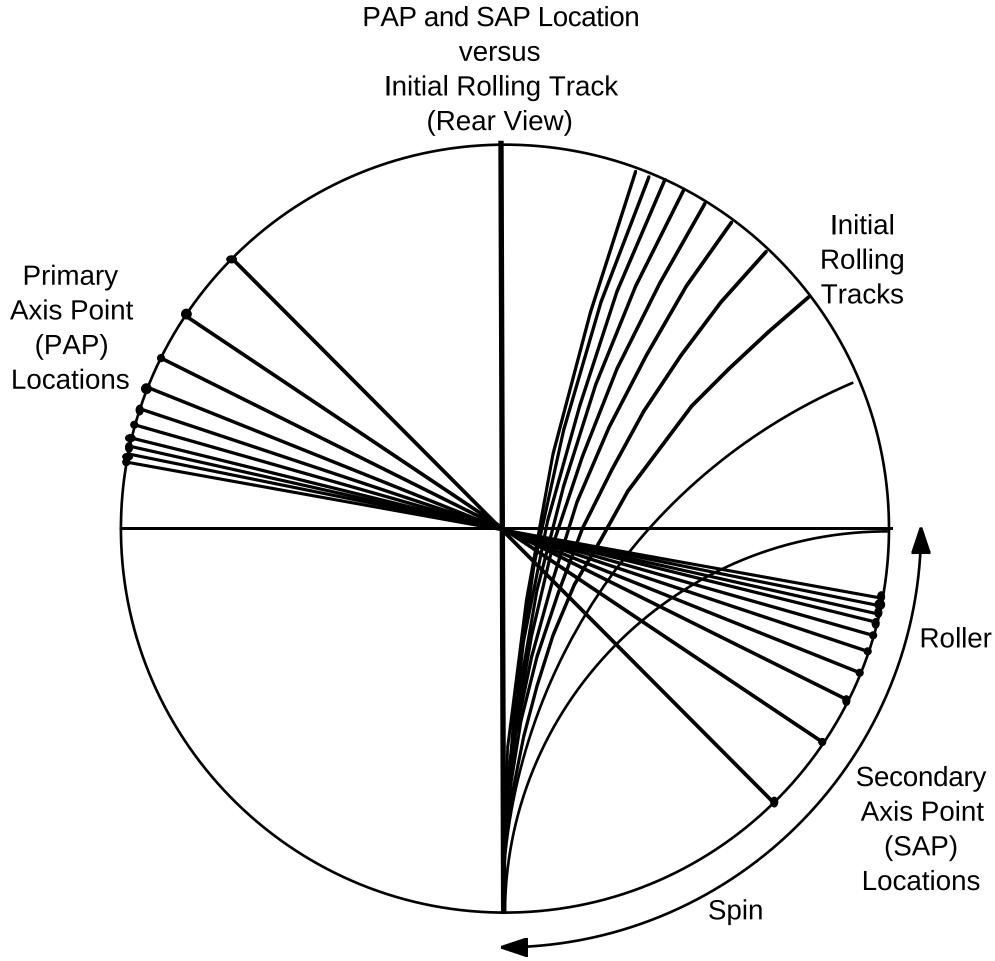

Ball Path
Direction
Equal
Forward
and
Sideways
Rotation
Flare Axis Point
(Bow Tie)
View
45 Degrees
Axis
Rotation


Ball Path
Direction
Mostly
Sideways
Rotation
Flare Axis Point
(Bow Tie)
View
67.5
Degrees
Axis
Rotation


Ball Path
Direction
Flare Axis Point
(Bow Tie)
View
90
Degrees
All Sideways
Rotation



A full roller is the vertical line. They spin the ball very very little. Their track is usually between the fingers and the thumb.

Most bowlers are near the first curved track shown near the vertical line. That's what commonly termed as a 3/4 roller.

Spinners have a track closer to the bottom, a smaller diameter track.

The Taiwan Spinners have a track that is almost a dot at the very bottom of the bowling ball.

The Necktie Model for a Weight Block
The next step in the evolution of a proper model for a real bowling ball is that of a weight block shaped like a necktie. Is there such a weight block?

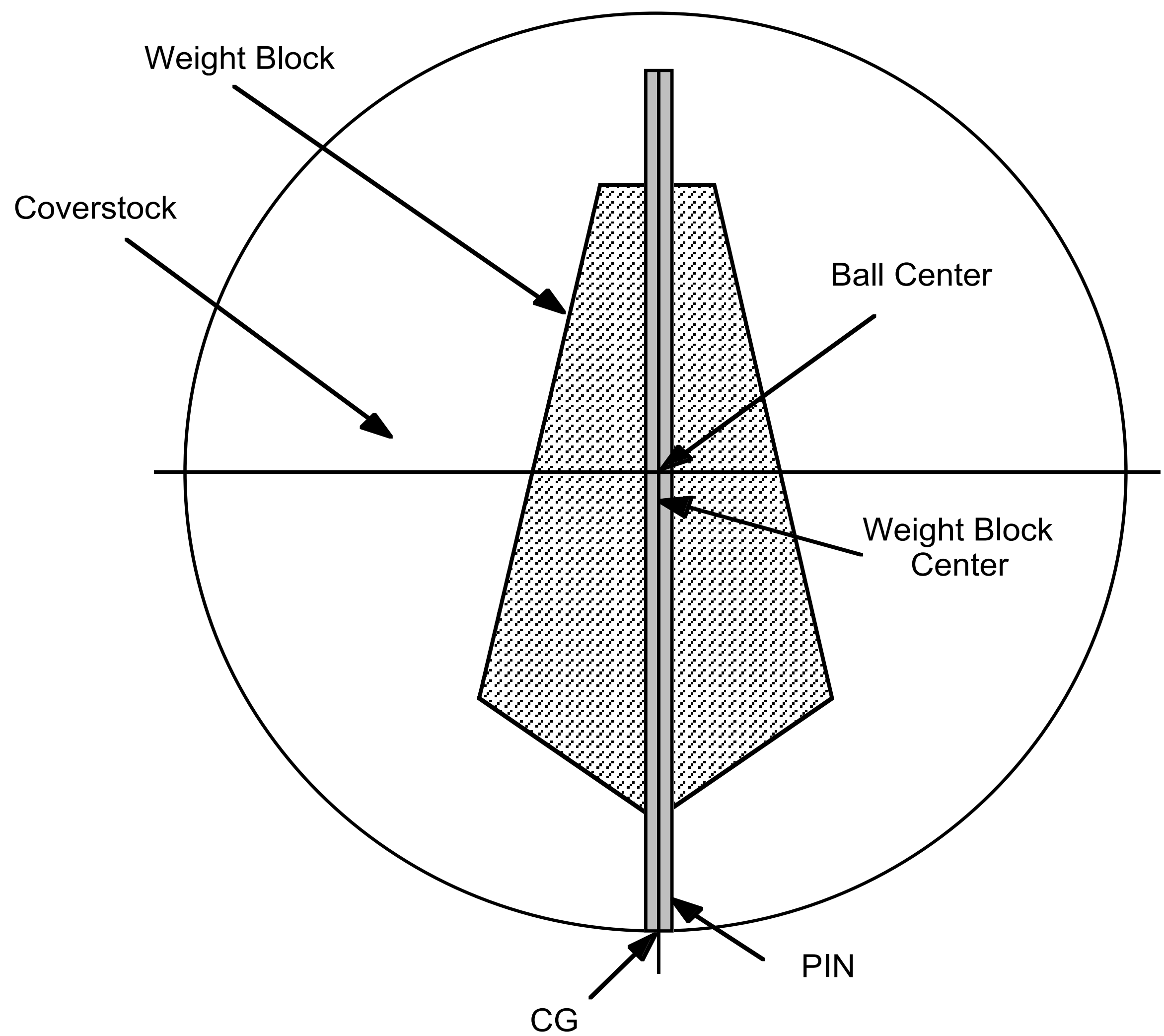
No, but it was easy for me to draw and it sorta looks like some of the weight blocks out there and I didn't want any legal battles about copyright infringements happening at a later date.

(Two weeks after publiication of this document three companies may rush to begin seventeen new bowling balls each of which is a design based upon some dumb necktie model for a weight block). Heh, it's just a model guys. Nothing more, nothing less.

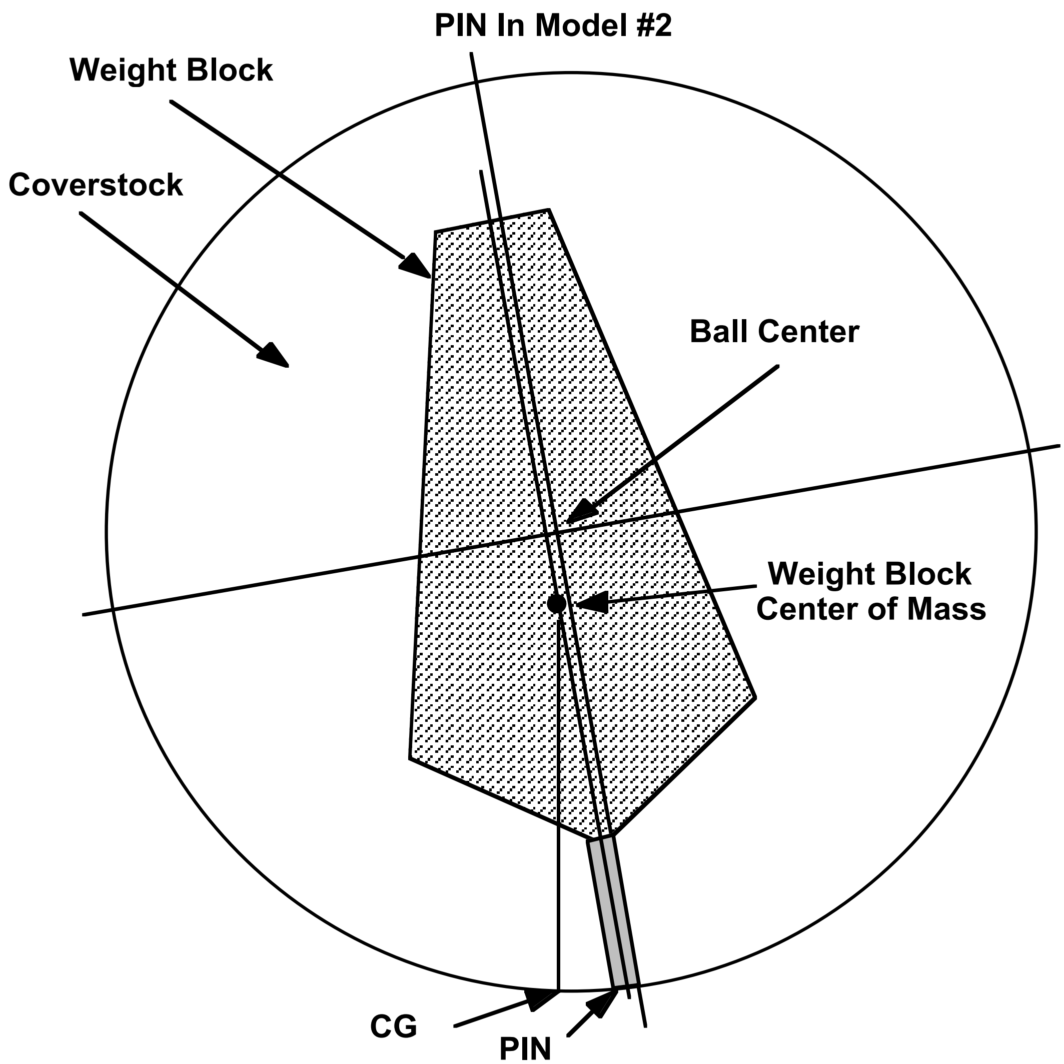
Note that the center of the ball for this first graphic of the Necktie Model is a little above the center of the mass of the weight block. If you were to float the ball on a cushion of air as they do in ball manufacturing facilities, the ball would reorientate itself so that the center of the mass of the weight block is closest to the surface of the ball. That line will point straight down from the center of mass, the center of the weight block. That point on the surface of the ball is what the manufacturers designate as the Center of Gravity (CG) of the ball.

The difference in PIN-In and PIN-Out balls can also be easily shown with this model. PIN-In ball designs are bowling ball designs that have the weight block positioned so that the CG is 1" or less from the PIN. PIN-Out ball have the CG more than an inch away from the PIN. Shown below is a perfectly aligned PIN-In ball

PIN In Model #1

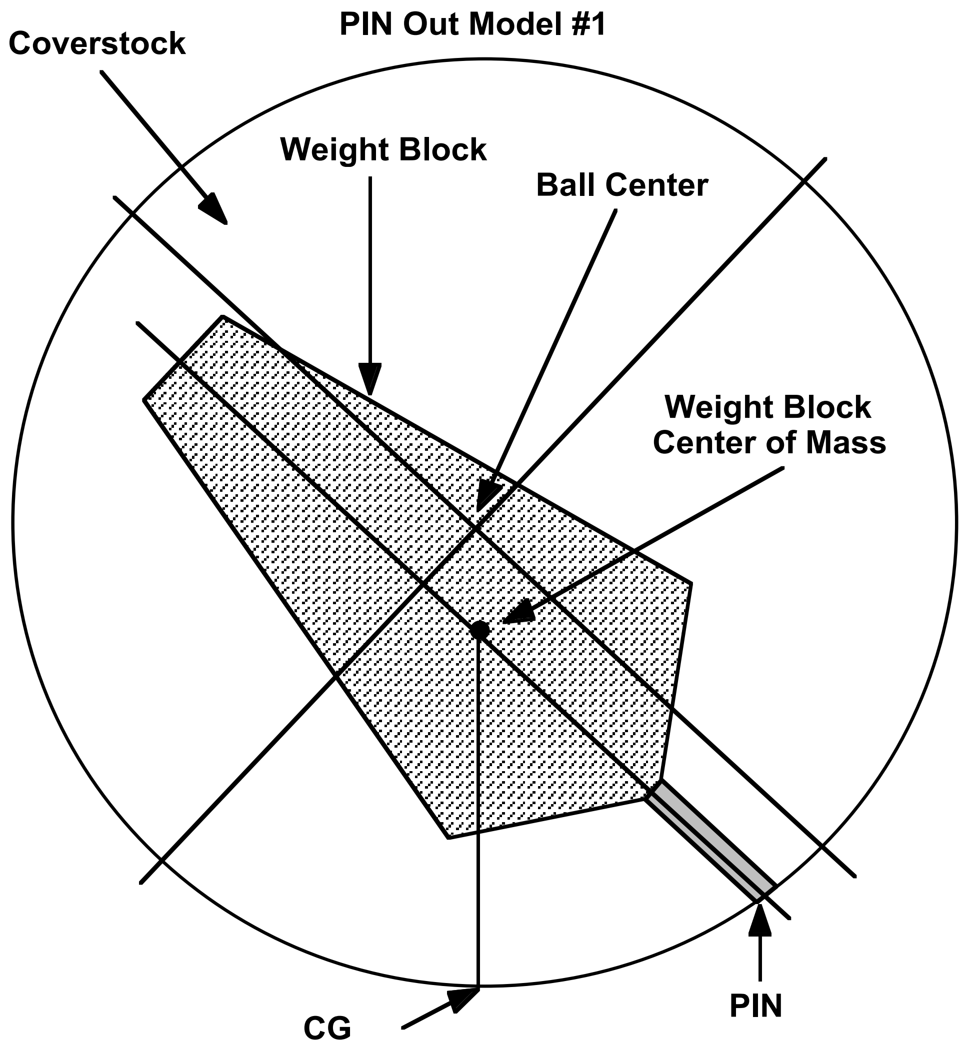


Another orientation that is still a PIN-IN design is shown in the graphic below. Generally, PIN-In balls focus their CG and PIN dynamic effects at the same time since the CG and PIN are at about the same physical location on the ball surface. Note that the ball weight block is rotated and shifted so the center of the ball is above and slightly to the left of the center of mass of the weight block.



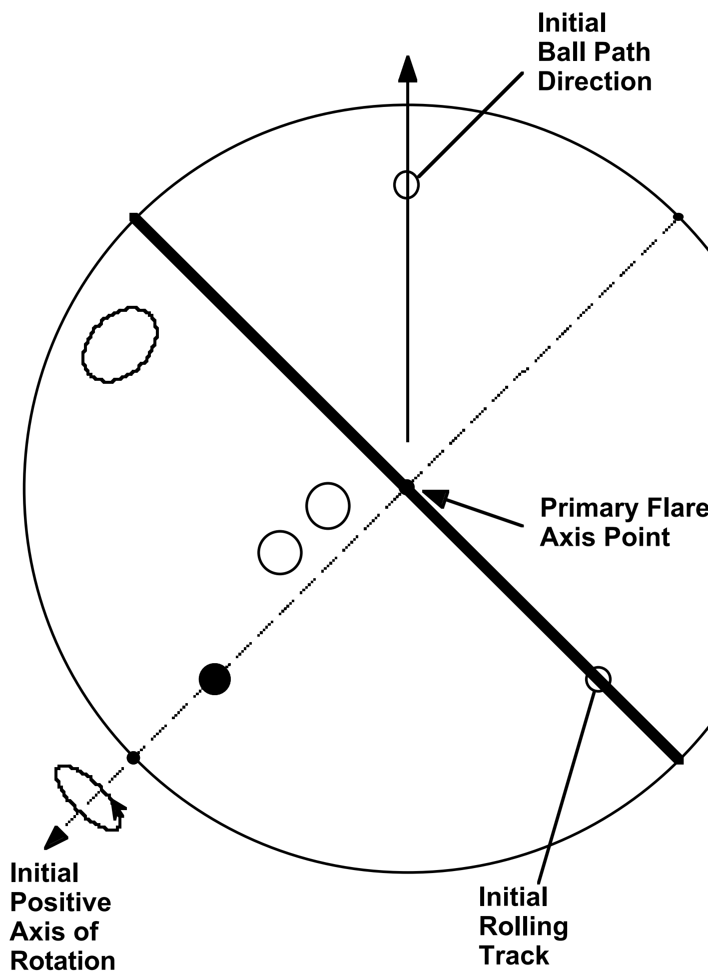
PIN-Out Ball Designs

Next is the same model showing a PIN-Out ball design. Now the PIN is farther than the 1” limit for declaration of the ball as a PIN-In ball design.



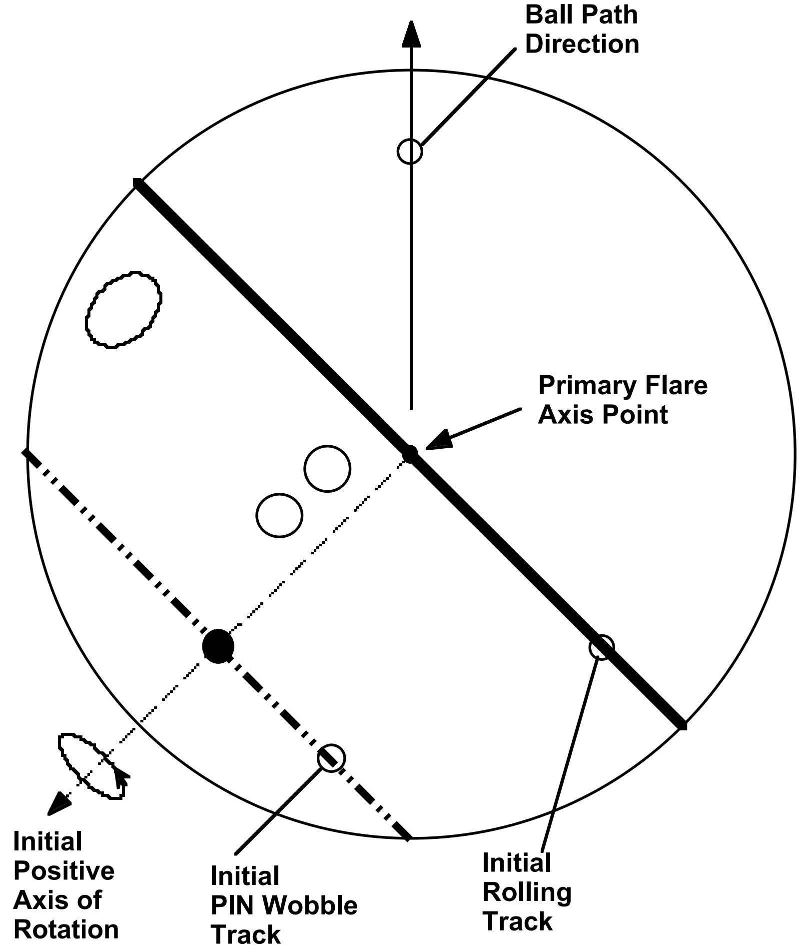
The Release

The Initial Position and Orientation of a Bowling Ball after Release
When released, the ball is given forward roll as well as sideways roll. The axis of rotation for the sideways roll points directly back at the bowler. The forward roll axis points across the lane from right to left for a right handed bowler. The combination of the two rotations give a total rotation axis that points backward and to the left. How much in either of the two directions depends upon the relative magnitude of the two rotations. The graphic below shows the initial axis of rotation at about 45 degrees with respect to the forward roll axis which is about equal forward and sideways rotation imparted to the ball at release. Note that for this case the initial rolling track is at 45 degrees with respect to the ball travel direction.

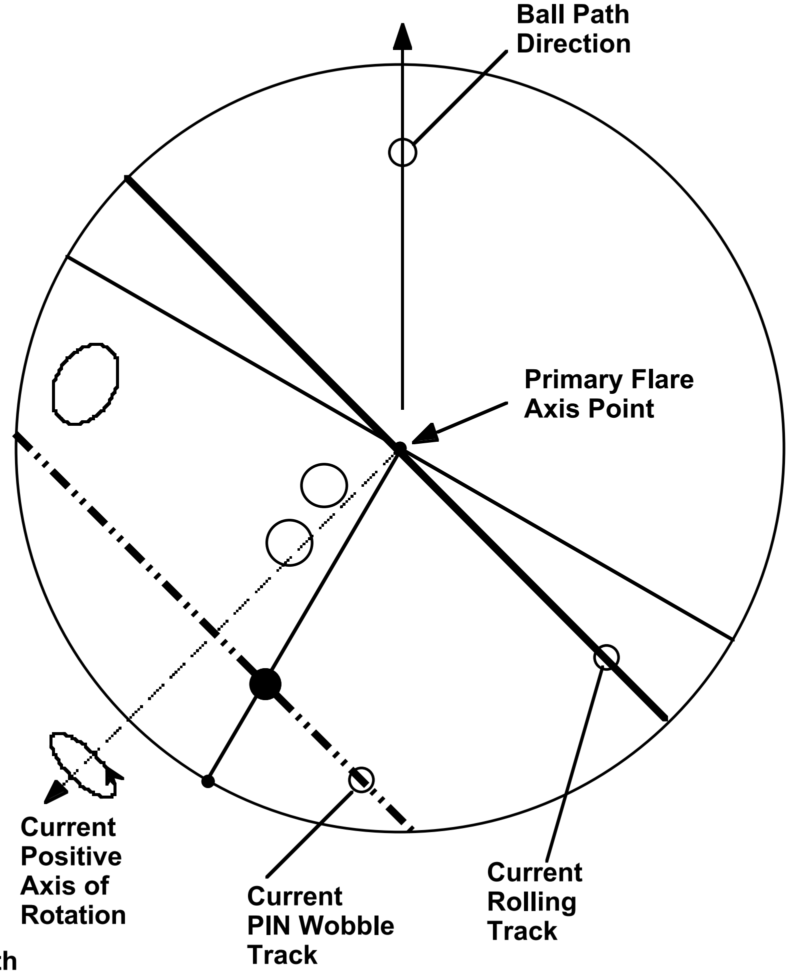


Wobbling/Flaring on Lanes Oiled 60 Feet Long and Seemingly, 60 Feet Deep
The series of graphics shown below detail a very smooth surface bowling ball released with equal sideways roll and forward roll on very very wet lanes. (The ball never wrinkles; it slides the whole 60 feet; it never breaks across the lane, but it does wobble and consequently flare throughout the entire rolling path, which in this case is a straight line).

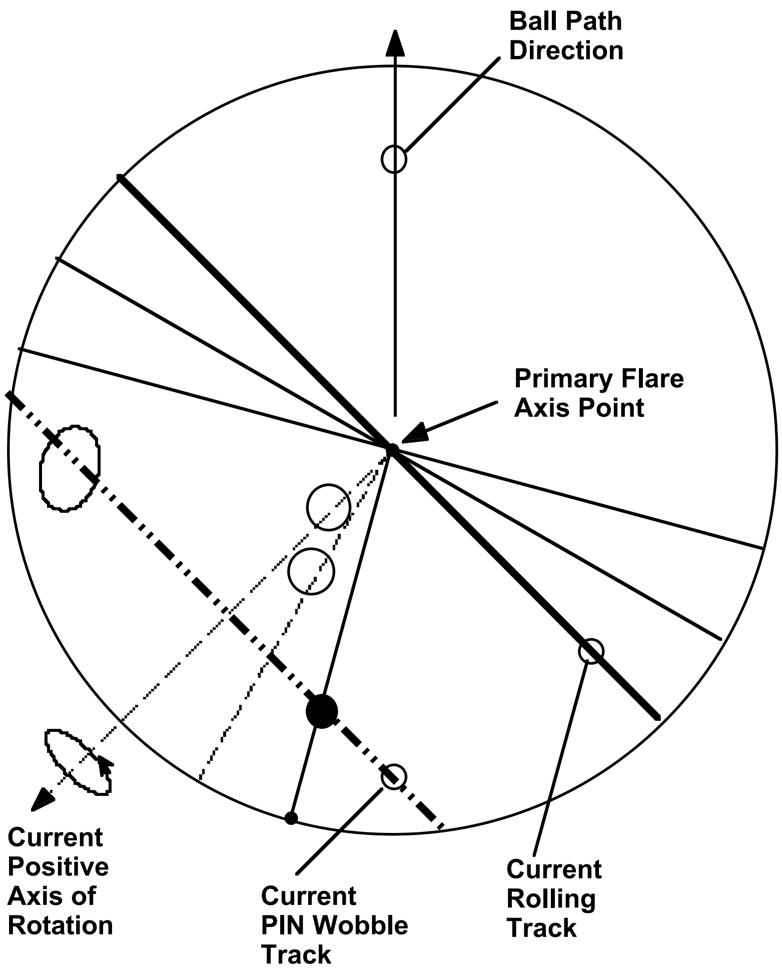
These graphics are included merely to show the nature of flaring on the surface of a bowlin ball. It's just a model.



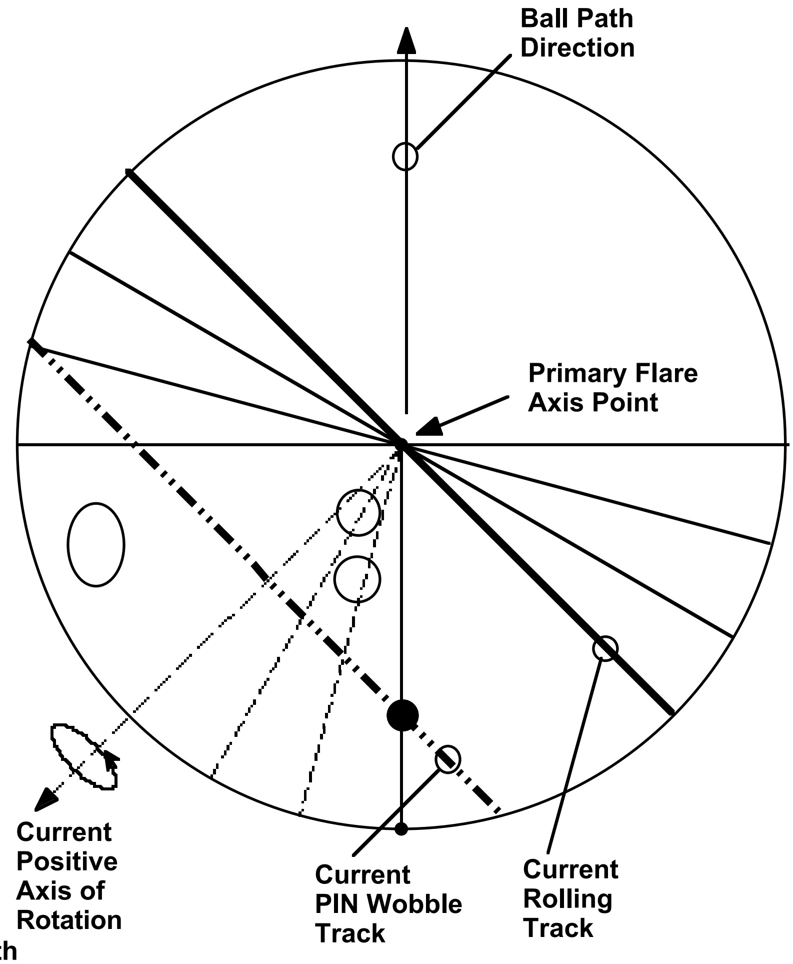
Super Wet Track #2



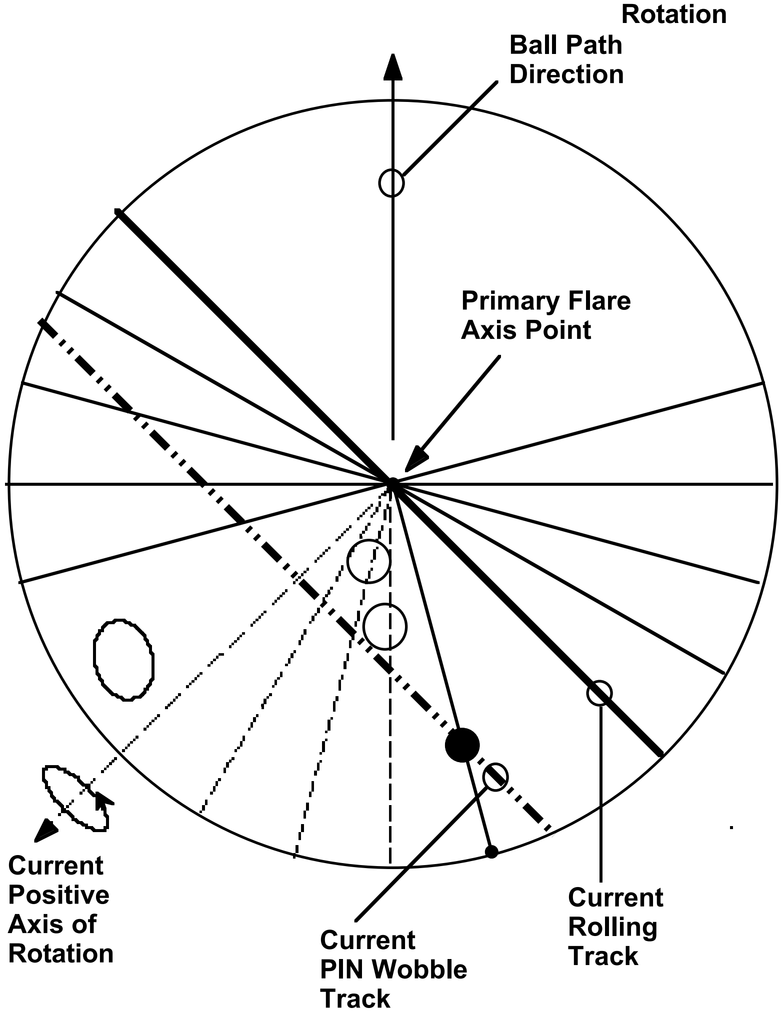
Super Wet Track #3



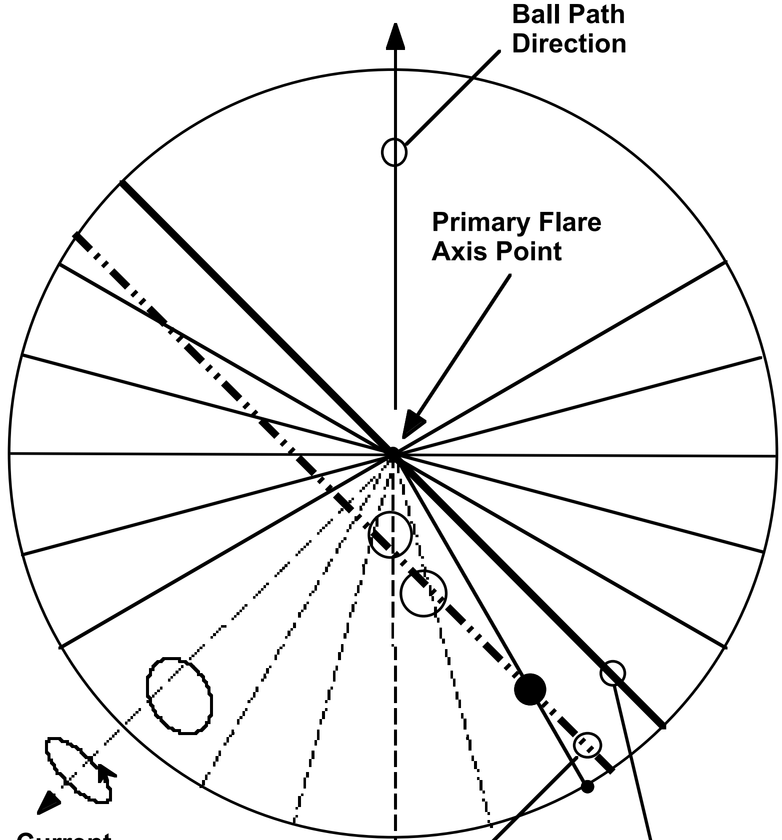
Super Wet Track #4

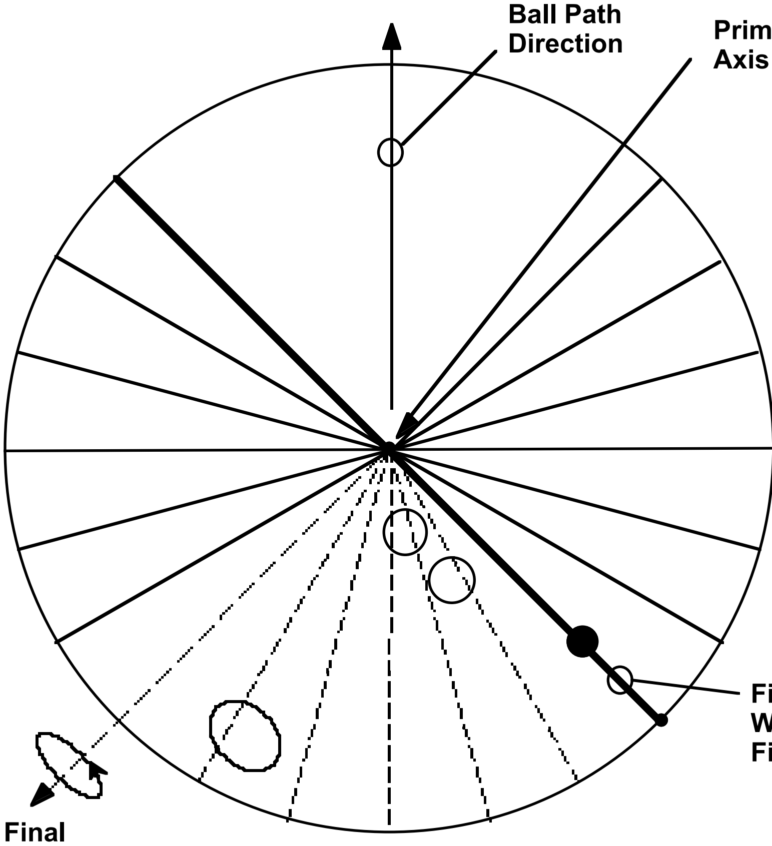


Super Wet Track #5



Super Wet Track #6

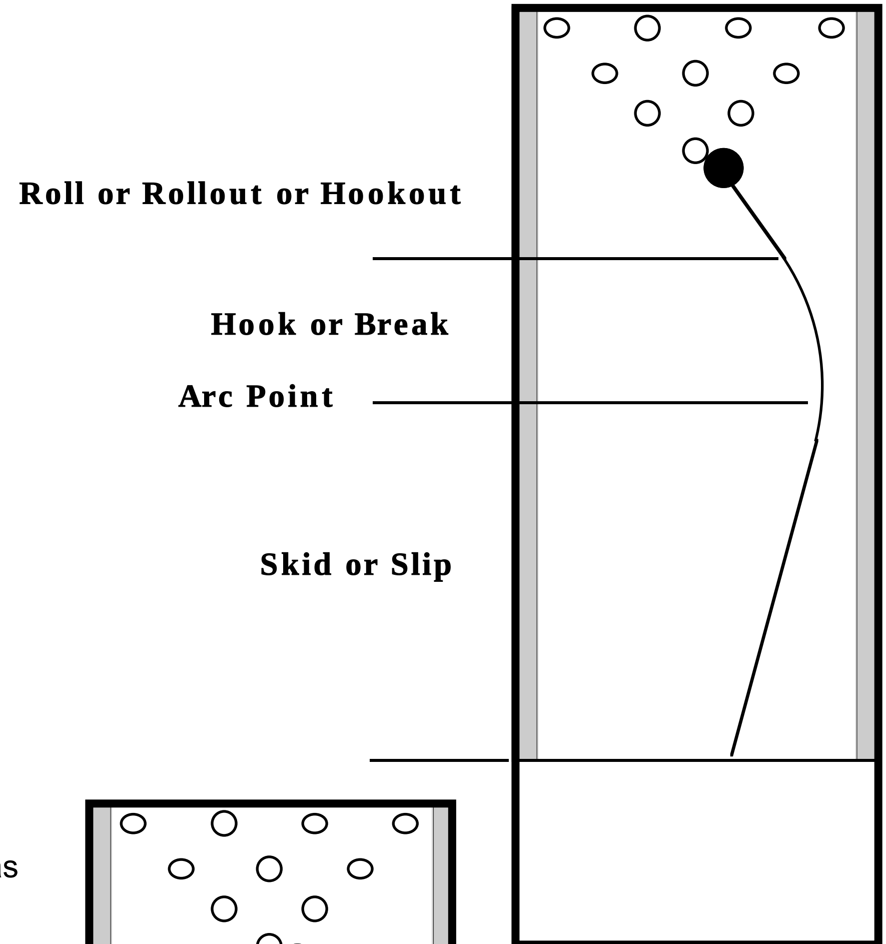




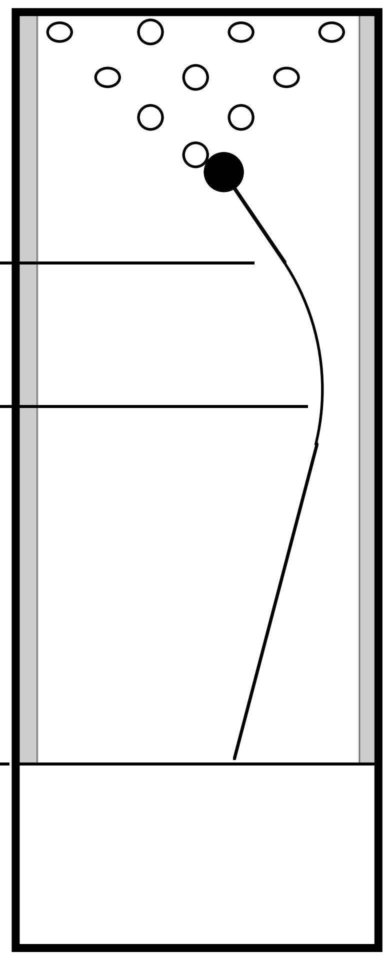
Final Super Wet Track

Note that the flaring distance for this model is 6 3/4” which is 1/4 the circumference of the ball.

There are some differences in the terminology used when describing the rolling path of a bowling ball. Historically, the accepted definitions vary as follows:



The definitions that will be used in this document are as follows:



Gravity, Friction, Centrifugal Force and Inertia (The Four Forces of Bowling)

After you release a bowling ball, only gravity, centrifugal forces, inertia forces and torques and friction can act on the bowling ball. Your job is done. You have imparted forward and sideways rotational energy into the ball and you have propelled it down the lane with translational energy in the desired direction. What happens now is up to "The Four Forces."

Gravity

After everything is said and done with all of the possible positions that a mass imbalance can get into, what dominates overall is the fact that gravity will always pull any and all mass whether imbalanced or not, in a direction pointing straight downward. And, I don't think that any manufacturer will introduce an antigravity ball anytime soon. Gravity is a minor force, but it is there all of the time. It ultimately determines the friction forces felt at the surface. The heavier a bowling ball is, the more friction is felt at the surface. The actual difference between a 16 and a 15 pound ball is small and may be negligible, but there is a difference.

Friction and Traction (Ball Surface)

This is by far the dominate force of the group of four forces. It is dependent upon the weight of the ball (the gravity effect mentioned above). The heavier the ball, the greater the inherent friction. It is also dependent upon the surface roughness, porosity and hardness of the ball. The reactive resin balls add an additional effect, that of tackiness on the drier lane surfaces. The more reactive, the tackier and higher the friction is. Friction and traction are the mechanisms that allows the ball to hook across the lane surface.

Centrifugal Force

When a mass imbalance rotates, centrifugal force tries to force it outward from the center of rotation. This is the dynamic mechanism that causes flaring. It tries to pull the mass imbalance of the ball over to one of the preferred axes of rotation (usually it pulls the Pin over to the rolling track).

Inertia (Translational)

When you release the ball, you propel the ball in a desired direction. In doing so, you impart translational energy into the ball. Newton's 2nd Law defines mass as a substance that doesn't like it's velocity changed. You have to apply a force to get the velocity to change. That's where the equation F=MA comes from. (Force = Mass times the Acceleration of the Mass).

Friction is the force that is applied to get the bowling ball to change it's velocity. The force that the friction force is acting against is called the inertia force. It's what the ball has after you have released the ball. The inertia force keeps the ball going down the lane.

Inertia (Rotational)

When you release the ball, you also impart rotational energy into the ball. You "lift" the ball from the back of the ball and at the side of the ball causing both forward and sideways rotation. That energy is also opposed by the friction forces at the point of contact at the lane surface.

The rotational inertia (inertia torque) keeps the ball rotating while it is in the slippery portion of the lane surface. Since there is very little force to stop the rotation, it just keeps rotating . . . . until the friction at the end of the lane surface starts to oppose the rotation of the ball in all directions.

What the Ball is Doing

A bowling ball is always rolling unless someone is holding the ball down to the surface of the lane and pushing it from the rear like a heavy stone (that's illegal by ABC rules).

In fact if the ball has enough rotational energy, it is always slipping until the very end of its travel down the lane until the rotational energy is depleted. So, let's denote the state as Slipping/F/S/T/H meaning that the ball is rotating faster than the travel both in the forward and sideways direction of the ball and although we don't like it , we spin the ball a small amount about an axis at the top of the ball, and is still hooking with respect to the direction of travel of the ball. So the ball starts out with a (Translational Rolling/Slipping/Flaring/F/S/T) status.

Translational Rolling/Slipping/Flaring/F/S/T/H
Translational Rolling – the ball is a spherical object moving down the lane surface.
Slipping - the ball is still travelling down the lane rotating faster than it is travelling.
Flaring - the ball is flaring, still trying to orientate itself so that the Pin end up at one of the preferred axes of rotation (usually with the Pin on the final rolling track.
F - the ball is rotating faster than it is traveling in the forward direction, the direction that the ball is travelling at that instant.
S - the ball is rotating sideways faster than the ball is travelling sideways with respect to the direction that the ball is travelling at that instant.
T - the ball is spinning about the vertical axis pointing out of the top of the ball at that instant.

When the ball begins to hook, we will add an additional parameter "H" to denote that the ball is still moving sideways with respect to the direction of travel of the ball at that instant.

H - the ball is still moving sideways with respect to the direction of the ball at that instant.

Status #1
So after the ball is released, it in the Translational Rolling/Slipping/Flaring/F/S/T status.

The Oil Transition Area
In almost all oil patterns on the lane surface, the oil is tapered both laterally and in the direction toward the pins. So, it decreases density as it gets farther down the lane surface. Usually, the oil is applied at a specific density (end of oil application) and then it is gradually decreased until at some point down the lane (end of the transition area).

The Bowling Ball Surface Texture and the Transition Area
As the ball enters the transition area, it begins to lose more energy. The actual height of the oil above the lane surface is less and more and more of the ball surface is making contact. (the footprint of the ball on the actual lane surface is getting bigger.

It is in this area where the texture of the ball makes all of the difference in the world. That texture (the roughness of the ball) determines how much energy of the ball begins to be depleted. Note that all parts of the energy are depleted if the texture is rough enough at this point.

Those little spikes sticking out of the surface of a particle ball start poking through the oil and rubbing on the lane surface and the ball may, in a very subtle manner, begin to move sideways during this transition area of the travel down the lane.

For most smooth surface bowling balls on lane surfaces that are also smooth with a reasonable amount of lane oil, the ball is still in the same mode. **(Translational Rolling/ Slipping/Flaring/F/S/T)**

End of the Transition Area (End of the Lane Oil)
It is at this point that the energy of the ball begins to be depleted for all bowling balls regardless of their weight, design and surface texture. The ball is now hooking toward the pocket. The friction that was not felt at the ball surface before is now beginning to drain the ball of energy.

Status #2
The status is now (Translational Rolling/Slipping/Flaring/F/S/T/H).

All of the components are still present and the ball is hooking toward the pocket.

Sideways Rotational Energy, Top Spin Rotational Energy and Flaring are Depleted
The ball is now orientated so that the ball is rolling with the Pin on the rolling track at that instant.

Status #3
So the status is now (Translational Rolling/Slipping/F).

The ball is still rotating faster than it is travelling forward in the direction that it is going at that instant.

Once the extra sideways energy is depleted, the ball continues in a straight line, it unhooks, but hopefully the ball still has extra rotational energy in the forward direction. If this is the case, the ball is still in a very high friction state at the surface of the ball and still has a tremendous amount of drive.

It is also at this instant that the Top Spin imparted to the ball is assumed to be depleted.

If you have placed an Axis Dot on the ball (a dot at the initial axis of rotation, the PAP), the plane defined by the spinning Axis Dot circle will appear to end up being vertical because all of the Top Spin is depleted. The axis of rotation no longer has any vertical component. It's parallel to the lane surface pointing off to the left somewhere depending on the angle of attack at that instant.

If you don't move that Axis Dot circle plane to the vertical position, you're spinning the ball too much. You haven't released all of the top spin energy. You're coming around the side of the ball too much while you're releasing the ball and you end up with the ball still spinning about the vertical axis at the impact with the pins.

Oh, darn,. . . . another waste of energy!

Editor's Note:
When you think of all of the ways that you waste energy, remember that it's mostly the lack of forward driving energy that causes the corner pins to be left standing. But we all like those corner pin spares don't we.

Yeah . . . right.

So the first moral to this story is that the more you get behind the ball, the more forward rotational energy you place into the ball and the more likelihood that you will not leave corner pins. Other things complicate matters involving the corner pins, but inadequate forward rotational energy is the leading contender.

Okay . . . . . everyone say it now please.

I will work on staying behind the ball.
I will work on staying behind the ball.
I will work on staying behind the ball.
I will work on staying behind the ball.

Another Editors Note:
Yes, you should work on staying behind the ball. The ball simply packs more of an impact with the pins when you do that. But, you should not force your hand behind the ball during the forward motion of the swing to the release of the ball. Make the swing a natural swing. Make it so natural that you don't need to think about it.

Force your hand as much as you want during practice,that helps you change your natural swing to become a more behind the ball orientation. On league nights, when it comes to competition, just let the swing do whatever it does naturally and just maybe that practice will pay off. Maybe your swing now is in a more behind the ball naturally.

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And now ladies and gentlemen, what we've all been waiting for, that main attraction, the impact with the Pins. (Drum roll in the background followed by symbols clashing together).

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The Ideal Time to Impact the Pins (Translational Rolling/Slipping/F).
It is at this instant that you want the ball to impact the head pin. You don't want to waste any more energy. You want the ball to impact the head pin with the maximum amount of energy possible. The time is now. It's that remaining forward rotational energy above the actual travel speed of the ball that will destroy the rack of pins.

That is the reason why "getting behind the ball" is stressed so much. It persuades you to put less energy into the sideways rotation and more into the forward rotation. You need just enough sideways rotation to be able to get the ball to the pocket, nothing more, nothing less.

In the past this has been noted as the rollout of the ball (when the ball straightens out, stops curving). I personally don't like that term for what has actually happened. I prefer to call it hook out because that's where the ball stops hooking.

So, ... hi ho, hi ho . . . unhooking we will go. The ball hooks out; it doesn't roll out.

Now, on to the rest of this epic narrative.

Past the Hook Out Point
The rest assumes that, for some reason, the ball has not impacted the pins yet and the energy is still being drained from the ball by the friction on the interface of the ball with the lane surface. The ball is still at a (Translational Rolling/Slipping/F) status.

Status #4
The ball has straightened out (hooked out) and is in the (Slipping/F) status. It still has excess forward rotational energy.

Roll Out Point
Once the extra forward rotational energy is depleted, the ball no longer is rotating faster than it is traveling down the lane surface. At that point it is simply a rolling mass no longer slipping at the point of contact with the surface. Hence the status **(Translational Rolling).**

Status #5
The ball is just a rolling hunk of plastic or some form thereof (Translational Rolling).

The Roll Out Flip
The instant that this occurs, you will see sort of a flip of the ball. It is actually the realignment of the ball so that the greatest imbalance, usually the Pin, is rolling in the same direction as the ball.

Before, while rotating faster than the travel down the lane causes more friction felt at the point of contact, the drive of the ball now depends totally on the static friction properties at the surface of the bowling ball combined with the friction properties of the lane surface.

You can easily demonstrate the Roll Out Flip by rolling the ball with backward spin. Try to make the ball spin about an axis pointed to the opposite side of the lane. Release the ball with your fingers in the 12 o'clock position pushing with your thumb. The ball will get a few revolutions in the reverse direction until all of the rotational energy is depleted and then it re-orientates itself; it flips to the pure rolling mode. Some bowlers actually bowl this way. (And that's why we need coaches).

So, now the ball is simply rolling. Rollin, rollin, rollin . . . Rawhide!

And, much more docile than Clint Eastwood was in that TV Show, the state of the ball is more like a simple hunk of plastic.

If it finally impacts the pins, the pins control the ball instead of the ball controlling the pins.

Not good guys, not good.

Translational Rolling is what we all start with when we begin to learn to bowl. We must make an effort to get past this level of ball dynamics.

The Little Boy that Could

Okay, in a few instances some of the very small Pee Wees will roll the ball and it will simply not have enough energy for the ball to get all of the way to the pins. The friction of the ball surface/lane surface interface has simply drained all of the energy.

The ball stops.

I have witnessed a nine count leave by a bowler. He rolled the ball normally. He had his normal speed of 5 miles per millennium. He was a little guy. But he had lots of heart and very good aim. He rolled it straight down the middle of the lane.

The just barely made it to the rack of pins just slightly to the right of the center of the head pin. It was more of a push than an impact, but the head pin went down nonetheless and the ball stopped and nothing else moved.

He was ecstatic; he jumped up and down and raised his arms in joy. He had accomplished what he had intended.

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As he walked back to the setee area, I reached out to congratulate him and I stooped down and gave him a “high five.”

It was at that instant that I saw a vision of this same bowler as a young man about 18 years of age bowling his final frame in the first ever Olympic Bowling Singles Competition.

He smashed the pins and probably broke at least seven of them. He was given the first ever Gold Medal for Singles competition at the Olympics. He really enjoyed the game regardless of the competition skill level.

He was a bowler.

I waved goodbye as he walked away with a big smile on his face.

The future was his, it was his destiny.

He waved back and as he looked into my eyes, I kind’a got the feeling he already knew.

He wanted to be the best that he could be.

The Roll of the Ball

Instability of the Drilling Design of the Bowling Ball
You make the decision that this bowling ball will be drilled so that the PIN is located at the leverage position. That means the PIN is exactly halfway between the two preferred axes of rotation of the bowling ball.

Using a tall cylinder as a model, there are two distinct preferred axes of rotation. One is about an axis through the center of the cylinder down the length of the cylinder. The other is about an axis through the center of the side of the cylinder halfway down the length of the cylinder. Spinning the cylinder about the second axis (on the side of the cylinder) yields the most rotational inertia. (Higher Radius of Gyration).

A bowling ball has two preferred axes of rotation, but much like a pencil, the dominant one is the end over end rotation. For a bowling ball, the end over end rotation is manifested when the track of the ball is right over the PIN on the ball.

The bowling ball really really wants to rotate with the PIN on the rolling track. It will move it's axis of rotation until it gets the PIN right on the rolling track. (Flaring of the tracks).

Release
As the bowling ball is released, the thumb begins to release first while the palm and fingers are primarily behind the ball. As the ball begins to be released, the weight of the ball begins to be felt by the fingertips. The weight of the ball forces the ball to "fall" at the left side of the bowler's hand with the fingers still in the fingertip grips. As the bowler continues the release, the ball is positioned further left of the center of the direction that the ball is being propelled.

Finally, as the ball is finally released, the ball is positioned somewhat to the left of the hand (i.e. the bowler's hand is to the right of the center of the ball).

If the bowler is moving his hand more forward than upward at the side of the ball, he imparts a top spin on the ball.

Torques into the Ball (alias energy input to the ball, alias the spins you place into the ball, alias the "Lift" you put into the ball)
Depending on how much the bowler's hand is positioned at the final instant of the release, the torques imparted to the ball can include forward, sideways and top spin components of torque.

The more a bowler stays behind the ball during the release, the more forward torque is imparted to the ball. Forward torque tends to make the ball roll forward down the lane more.

The more a bowler's hand lifts upward while at the side of the ball before the release, the more sideways torque is imparted to the ball. Sideways torque tends to make the ball roll sideways across the lane more.

The more a bowler's hand is moving forward rather than upward at the side of the ball during release, the more top spin he places on the ball. Top spin is mostly a waste. (Recently though, a professional bowler from Taiwan, rolling a 13 pound ball utilizing a pure spinner release, won a major professional tournament).

Rev's into the Ball
The three torques that are imparted into the ball produce three types of rotation, forward rotation, sideways rotation and a vertical rotation (also called the spinning rotation).

The forward rotation is the rotation of the ball about an axis pointing leftward across the lane. If you hold your right hand out with your palm facing downward and your thumb to the left, your fingers represent the direction of movement of the top surface of the ball and your thumb represents the direction of the forward rotation axis.

In the same way, the sideways rotation can be modeled. If you hold out your right hand with your thumb pointing rearward and your palm facing left, your fingers represent the direction of the movement of the top surface of the ball and your thumb represents the direction of the axis of rotation.

Also, in the same way, the top spin can be modeled. If you hold out your hand so that your palm is facing left and your thumb is pointing upward, your fingers represent the direction of the movement of the right side surface of the ball and your thumb represents the direction of the axis of rotation.

Only the sideways and forward rotations are of importance to the great majority of bowlers. Consequently, the top spin will not be included in the following analysis.

The Combined Axis of Rotation
The axis of rotation for the forward roll points to the left. The axis of rotation for the sideways roll points to the rear. The combined rotation has an axis of rotation that points somewhere between the rear and the left side depending upon how much sideways torque is imparted. If there is an equal division of applied torques, the combined axis is halfway between the two separate axes. That means the combined axis is 45 degrees from the rear and the left side.

Impact with the Lane Surface
When the ball finally impacts the lane surface, it still rotates in much the same manner as it did in the air just after release. The impact itself does not significantly affect the dynamics. (Primarily because there is so much oil in the front end of the lane surface).

Slipping on the Frontend Oil
Depending on the friction between the ball surface and the actual lane surface, the rotational speed begins to be decreased. Since the lane oil is usually heavy at the frontend, the decrease is almost unnoticeable. The ball simply slides as it rotates about both the forward and sideways axes. If however, the ball is sanded with a low grit sandpaper and has a very rough surface, the ball will start to break earlier but not necessarily more overall.

Initial Rolling Track
Just after the ball impacts the lane surface and continues to rotate, an initial oil track is created on the surface of the ball. If you place a small piece of white tape at the center of the hemisphere defined by the initial oil track, and roll the ball, the tape will show how the axis of rotation changes during the roll of the ball. That axis is on the same side of the ball as the gripping holes. The tape, at that location, is called the Axis Dot.

Just after impact, the Axis Dot will appear to be almost stationary and then gradually will become a larger and larger circle.

Instability of the Dynamics of the Ball

The instability is the “desire” that the ball has to re-orientate itself to the rolling-over-the-PIN orientation. When the ball was drilled, it was essentially decided how much instability you wanted to start the ball with just after release. The more instability, the greater the possibility of increased flaring and breaking of the ball. The increased instability combined with the friction between the surface of the ball and the lane surface allows the ball to break across the lane surface.

Flaring

Instability of the dynamics causes flaring. Remember the dynamics instability will force the ball to usually seek out a rotational axis orientation for the rolling track to be right across the PIN. Flaring is that change in orientation of the axis of rotation.

Note: The ball may be drilled in such a way that the Pin will seek to move over to the initial axis of rotation. That particular drilling is called Axis Drilling because the Pin moves over to the initial axis of rotation. This drilling usually produces much more mellow ball path. Consequently, it is used infrequently except for very dry conditions.

Friction and Traction on the Frontend Oil

Sideways rotation of the ball and friction and traction at the surface of the ball cause the ball to move left across the lane. In the frontend part of the lane surface, however, there is usually a large amount of lane oil. That decreases the amount of friction between the ball surface and the lane surface. So, consequently, the movement left in the early part of the roll of the ball may not even be noticeable depending on the ball surface friction and traction.

Even though there is little friction, and little movement left across the lane, the flaring is still occurring. It is caused by the instability of the dynamics and the need for the ball to search for that end over end rotation across the PIN.

Friction and Traction after the End of the Oil

When the ball starts to enter a higher friction and traction area at the rear part of the lane surface, the ball begins to get adherence with the lane surface and begins to move left appreciably, assuming there is still some sideways rotational energy remaining in the ball

Break after the End of the Oil

Because the ball is flaring, new fresh surface is exposed to the lane surface at all times. That new fresh surface has little or no lane oil on it. The greater the surface friction and traction, the greater the ability of the ball to break across the lane. If the bowler has imparted enough sideways rotation and the flaring is pronounced enough to separate the rolling tracks and the surface friction/traction of the ball is enough, the ball breaks across the lane with a vengeance.

Final Orientation of the Rolling Track

Ideally a bowling ball needs to get to that “over the PIN” rolling track orientation just as the ball impacts the head pin. That orientation has the maximum rotational inertia.

Impact Location at the Head Pin

The ideal head pin impact is such that the line drawn between the center of the ball and the center of the head pin, if extended would intersect the centers of the 2, 4 and 7 pins. That means that the center to center line is at 30 degrees with respect to the right side of the lane. That does not mean that the ball is traveling at 30 degrees with respect to the right side of the lane. It means that, as the ball is trying to pass by the head pin, it clips the head pin so that the line of centers between the ball and the head pin is at 30 degrees.

Angle of Attack into the Pocket

The angle of attack is the angle of the actual path of the ball as it impacts the head pin. There are many successful angles of attack but the key is to have enough angle of attack so that the succeeding impacts results in the 5 pin being knocked down. If the angle of attack is not high enough, the 5 pin will not be impacted by the ball.

Conversely, if the angle of attack is too high, the 9 pin will not be impacted (and many other just wonderful spares including some really weird splits can occur).

Of the two ends of the spectrum, lower is better, but harder to consistently maintain.

An angle of impact of 4 to 12 degrees is about the right range. So, 8 degrees is about average. (Walter Ray Williams, one of the best professional bowlers of all time, attempts to get an angle of attack of about 4.7 degrees. That works best for him. Your best angle will depend upon the speed and dynamics of your bowling ball).

Speed of the Ball just before Impact with the Head Pin

Speed is another important factor. The higher the speed, the greater the energy available for knocking down the pins. But, as the speed increases, the pins tend to deflect upward instead of backward. Somewhere between 15 and 20 mph is a satisfactory number. Note that the 15 to 20 mph is the average speed measured from the point of release to the initial impact. A speed of about 15 mph just before impact with the pins is satisfactory.

How the Weight of the Ball Affects the Roll of the Ball

Weight affects the deflection angle of the ball. Generally, the deflection angle that the ball has after impacting a pin decreases as the weight increases. (Lighter weight balls deflect more).

How the Static Weight Balance of the Ball Affects the Roll of the Ball

The static weight imbalance has a small effect on the rolling path characteristic of the ball compared to the dynamic and surface effects of the ball. To a small degree the more side weight, the greater the break will be. Also to a small degree, the greater the finger weight and top weight, the greater the length of the delay of the break across the lane surface will be.

How the Radius of Gyration Affects the Roll of the Ball

The smaller the radius of gyration, the easier it is to impart rotational energy into the ball. Generally, the easier it is to rev the ball up. And, conversely, the higher the RG, the harder the ball is to rev up. For that reason low RG balls usually have oil tracks closer together than high RG balls.

How the Differential Radius of Gyration Affects the Roll of the Ball

The greater the Differential Radius of Gyration, the longer the flaring is on the surface of the ball.

How the Surface Reactivity Affects the Roll of the Ball

An increased surface reactivity increases the break across the lane at the backend of the lane.

Usually, highly reactive bowling balls are smooth surfaced and do not react well with the surface during the roll of the ball at the frontend of the lane where the lane conditioner is applied heavily.

How the Surface Porosity and Hardness Affects the Roll of the Ball
As the porosity increases and hardness decreases, the break increases.

How the Surface Bumpiness (Surface Roughness) Affects the Roll of the Ball
As the surface bumpiness increases, the overall amount of break usually increases. This is most easily seen as the sanding state of the surface of the ball. As the sanding grit number decreases, the overall amount of break increases. In the published ball guides, balls are sometimes listed with ratings for both the smooth and sanded state. The sanded state “almost always” has more hook potential.

There are exceptions, however. When a bowling ball has too much roughness (traction), it will do well in the early part of the oil but may not get enough friction (rubbing) at the rear part of the lane. The result is that the sanded ball actually breaks less than the smooth surface ball of the same type. This is especially true of an aggressive reactive resin ball. That type ball does extremely well on the dry back end. And, it is mostly because of friction, not traction. If you sand the ball, you decrease the total surface of the ball that makes contact with the lane surface. Hence, the ball will break less, not more.

The Hardness of the Inner Core of the Bowling Ball
Some bowling balls have a super hard inner core. The newest balls have either a ceramic or a titanium inner core. It is very lightweight, so it doesn’t add that much weight to the ball and it is extremely hard, so it doesn’t deform very much when impacted or when it impacts something else (like a bowling pin for example).

You want a bowling ball to act like a spring, not like a shock absorber. Damping (the shock absorber effect) is the primary effect that is changed by the super hard core. The less spongy the core is, the less it absorbs impacts. Ceramic and Titanium are less spongy than normal core material. They act as a better spring. Because the inner core absorbs shocks less easily, the energy exchange in an impact is greater. That means that the ball delivers energy to the pins better. (It hits harder).

When a bowling ball impacts a pin, both the pin and the ball are affected. If there is a sound made during the impact, and there always is, the energy to make that sound is taken away from the available kinetic energy of the ball. If the ball becomes deformed during the impact, and it always does, the internal materials are very slightly heated up. The creation of a slightly hotter bowling ball results in still more energy taken away from the kinetic energy of the bowling ball. The parameter that ABC specifies for governing the design of bowling balls with respect to their energy loss due to impacts is called the Coefficient of Restitution.

The limits that ABC specifies for the Coefficient of Restitution is between .65 and .78 . A ball that has a higher Coefficient of Restitution loses less energy during the impacts with the pins. A harder central core, like ceramic or titanium tends to make the ball have a Coefficient of Restitution at the higher end of the range of values that are legal, closer to the .78 value.

As a bowling ball travels through a rack of pins, each impact that the ball makes with the pins releases some of the energy of the ball into the impacted pins. So, after the first impact, the ball has a little less energy and it slows down. After the second impact the ball has even less energy and it slows down further. Successive impacts causes the ball to go slower and slower. You cannot design a ball that doesn't release part of it's energy at the impacts.

If the ball is going to lose energy as it travels through the pins, and it always will, the higher Coefficient of Restitution ball will lose less kinetic energy and will have greater kinetic energy longer for those later impacts.

Your Bowling Ball

Physical Parameters
The bowling ball is no longer just a hunk of rubber. Today's bowling balls are very well engineered designs. There are very strict rules for their physical and material design. The specification for the 13 to 16 pound balls are as follows:

Radius of Gyration	2.4	to	2.8
Differential Radius of Gyration within a ball about any 2 axes	0.0	to	.080
Coefficient of Restitution	.65	to	.78
Coefficient of Friction	0.0	to	.32
Circumference	26.704"	to	27.002"
Diameter	8.5"	to	8.595"

When a ball is drilled, where it is drilled determines how the ball wants to roll down the lane. Each manufacturer places a "center of top" marker also called the "Pin" of the ball. The Pin marks the geometrical center of the bowling ball weight block if the weight block is symmetrical. Drilling the holes more toward the fingers or toward the thumb allows the ball to curve sooner or later. Drilling the holes to the left or right of the center makes the ball to either arc (a banana shape) or hook snap (a hockey stick shape).

Surface Parameters
The surface of the bowling ball affects the scoring more than anything else. At present the only limitation is that the hardness be not less than 72 on a Durometer "D" hardness meter. Bowling ball manufacturers have produced new bowling balls that are smooth or porous or reactive resin or very rough at the surface. Some have the ability to curve even on slick or "oily" lane conditions. For oily conditions you would most likely choose a porous surface ball or a rough surface ball. For dry (little or no oil) conditions you would most likely choose a smooth reactive resin surface surface ball.

Surface Reaction
Most bowling balls are manufactured with a reactive resin as the outer surface. The reactive resin ball will slide through the oil and when it starts to roll over the dry area, it reacts for a greater curve at the end of the roll of the ball. Since it adheres to the lane in the pin deck area, it drives through the pin deck with a more powerful reaction. The reactive resin ball grips the lane better in the dry areas of the lanes.

If you take one of the reactive resin balls and heat it, the surface will become sticky. When the reactive resin ball rolls out of the oil and begins to roll on the higher friction dryer surface, the area of the ball making contact with the lane is slightly heated due to the increased friction. The reactive resin at the surface changes it's characteristics in the same way as described, it becomes sticky and adheres to the lane better. The result is that the ball violently curves left into the set of pins and continues to drive through the set of pins while still on the pin deck.

Particle Ball Reaction

The newest addition to the surface reaction bowling ball arsenal available is a surface with spikes sticking out. Particles are imbedded into the material that is used to make the cover stock. The result is a bowling ball that adheres better in the transitional area of the oil. The spikes are actually pieces of "mica" or some other hard material.

Depending on how many particles (the loading), how far they stick out (the size) and how rigid the spikes are (their hardness), the ball may exhibit both good traction and friction characteristics during the entire roll of the ball. This type ball probably has the greatest overall hook potential .

How Many Holes Can You Legally Drill in the Ball?

You can legally drill a hole for each finger and thumb of your hand and a vent hole for each finger and thumb of your hand and a single axis hole for balancing. An additional very shallow hole may be drilled in the area inside of the gripping triangle for purposes of measuring the hardness of the ball. None of these holes may be positioned so that the track of the roll of the ball coincides with the location of the hole. Although a hole is drilled for each finger and thumb of your hand, ABC does not require that you physically place a finger or a thumb in each of the holes.

So the answer is 12 holes.

Where Do You Drill the Holes?

Every bowling ball manufacturer locates the general center of gravity for the pro shop by placing a dot or indicator of some kind. The bowling ball comes from the manufacturer heavier in the area of the drilling area so that when it is drilled it will fall within the legal limits. A bowling ball may start out as an undrilled overweight 16 pound 4 ounce ball and become a legal 16 pound ball after drilling.

The extra weight in the drilling area is sometimes called the top weight.

The manufacturers also mark the location of the top of the weight block (the Pin). For symmetrically shaped weight blocks, it is the end of the axis that runs through the center of the ball.

Recently, some manufacturers have begun to mark the location of the imbalance at the side of the weight block called the Mass Bias Point (MBP).

The three points usually lie on an approximately straight line called the Pin-Mass Bias Line.

Locating the gripping holes with respect to the three points is the job for a trained professional. See your local PBPSI Certified Pro Shop for that task.

The Span

When your ball is drilled, the span should result in a slight stretching of the hand when the fingers and thumb are inserted. The tighter your span, the more your hand is stretched and the greater the lift will be. But, a tight span may become very uncomfortable after a few games.

Conventional Grip

The conventional grip is the oldest style of drilling a ball. The holes for the fingers are drilled to a depth so that they can be inserted to the second joint. This grip provides a surer grip and better ball control. It is used by beginning bowlers to get a good feel and practice in controlling the ball.

There are big disadvantages to this grip however. Since the fingers and thumb are so close together, when you release the ball, the fingers come out of the ball at about the same time as the thumb and there is inherently less lift, and hence, the ball, compared to a similar ball drilled fingertip, will curve less.

Most balls that belong to the bowling establishments are called house balls. Almost all house balls are conventionally drilled.

Fingertip Grip

A fingertip ball is drilled so that the finger holes are drilled for inserting your fingers only to the first joint. It is a less secure grip but the finger holes can be made tight enough so that you will not drop the ball. Since the holes are further apart from your thumb, when you release the ball, the fingers are in the ball a longer time after the thumb comes out. You fingers apply more torque (the lift on the ball) and the ball curves more.

The Size of the Holes

Each of the fingertip holes should fit snug. A good benchmark is whether or not you can pick up the ball by using just your fingers. If you can, they are probably tight enough.

The thumb hole needs to be snug also. It must be tight enough to pick up your ball by just using your thumb but it must be loose enough for a smooth release. A too loose thumb causes you to drop the ball during release. A too tight thumb will cause you to hang up and loft the ball a lot.

Ovalling the Holes.

Look at your fingers and especially the thumb. They are probably not circular even while they are out of the holes in your bowling ball. Now place your fingers and thumb in your bowling ball. Grasp the ball with a little pressure to simulate the weight you feel on your fingers when you actually roll the ball. Do not roll the ball however, merely look at your fingers and thumb. (This may require a mirror). Note that the shape of your fingers and thumb are much more oval than circular.

The holes in your bowling ball, both fingers and thumb should be oval in shape. They should feel tight when you put your fingers and thumb in so that under pressure of releasing the ball, they are still snug.

The Angle at Which the Holes are Drilled into the Ball.

The angle at which the holes are drilled into the ball affect your ability to release the ball properly. The angle is called the “pitch” of the hole.

All of the holes may be pitched in one way or another for a different effect. Zero pitch means that the hole is drilled at 90 degrees with respect to the surface of the ball, i.e. toward the center of the ball.

Pitching the finger holes toward the thumb hole is called forward pitch. This is also called "tucking" your finger holes. It results in a little better grip and more lifting ability, hence more curve. Too much tuck may be very uncomfortable however.

Reverse pitching the finger holes, away from the thumb, has just the opposite effect of forward pitch. It's more comfortable, but you'll get less lift.

The thumb may also be forward or reverse pitched. Forward pitch or "tucking" the thumb allows you to grasp the ball longer during release. Reverse pitch allows a quicker release.

As you place your hand on the top of the ball with your palm facing down, the holes can be pitched with the bottom going to the left, called left pitch. They can also be pitched to the right with the bottom of the holes slanting to the right.

If you're hanging up on your thumb, try a little reverse and left pitch on your thumb hole; you'll release the ball easier.

Adjusting the Span
Your fingers and thumb must both be snug inside their respective holes. As the temperature and humidity changes, your holes and span can seem to change. Sometimes everything will get loose; sometimes they will get tight. It's partly the ball and partly your hand that has actually changed.

About the only thing that can be done for a span that is too large is to taper the inside edge of the thumb hole to effectively decrease the span. You can easily do this with a small diameter round file and some sandpaper.

If you have tape on the inside face of the thumb hole, you can switch it to the outside face and approximately the same result will be obtained. The span will slightly decrease and the tightness of the thumb will remain about the same.

If a span is too small, you can switch tape from the outside face to the inside face, but you can't untaper the thumb hole. You can, however, use your index finger as a tightening device.

If you spread your index finger further out than usual, it will automatically tighten the span.

The Importance of the Thumb
The proper release of your thumb as the ball is rolled is probably second in importance only to where you roll the ball. If the thumb is too loose, it releases early and you don't get as much lift and the ball probably doesn't break as much. If it is too tight, you will hang up and you will probably pull it to the left or loft the ball.

<u>Before league practice starts</u>, check your thumb hole to make sure that it is comfortable and the proper adjustments are made. Right before league practice starts your thumb hole should feel very snug; make sure that it does. When you throw those first practice balls you will see that although it felt very snug, it may even feel loose. That happens because your thumb is not rigid, in fact, it's very plastic and tends to conform to the shape of the thumb hole. If it feels too loose even before you start practice it probably won't get any tighter by itself.

Also, if you wear a bowling glove, make sure that you check out the tightness of the thumb hole while wearing the glove. Most of the bowling gloves have wrist bands with Velcro straps that wrap around your wrist to adjust the tightness. When wearing the glove, your fingers and thumb swell slightly. Even with the glove on when you check the thumb hole fit before practice, it will probably feel a little looser when actually rolling the ball, so make sure it feels very snug before practice. After performing this ritual several times you will get a feel for the correct tightness before practice.

Vent Holes

When your thumb hole is ovaled and is very tight, you may have a problem getting it to slide out. Some bowlers hear a sound when their thumb slides out of the ball. It's kind a like pulling a cork out of a bottle; it makes a popping sound. The sound is not a good sign. It means that the ball is trying to hold onto the thumb. When you push your thumb into a tight thumb hole, you have pushed all of the air out. When you try to pull your thumb out, a slight vacuum is created while the thumb is sliding out. The only reason that you can get it out is that the hole doesn't exactly match your thumb and a small amount of air gets in around the edges. If the thumb matches the hole any closer, you may end up with it sticking on your thumb.

A small diameter hole drilled into the bottom of the thumb hole is the solution. It's called a vent hole. The actual diameter need not be more than about a 1/16 inch. ABC allows a vent hole for each finger and/or thumb hole not exceeding 1/4 inch diameter.

Although allowed by ABC, not many bowlers use a vent hole for their fingers. (If you are using a conventional grip, it can be useful however).

Bowler's Tape ®

Even after having your thumb hole drilled and ovaled, it still may not feel right when you deliver it. You can tighten your glove a little to swell your hand up, but maybe that's not enough.

"Bowler's Tape ®" is probably the answer. It is a product made by Bowler's Tape International" which is a subsidiary of AMF.

If you want to increase the span a little and make your thumb tighter, place the bowler's tape on the inside face of the thumb hole. If you want to tighten the hole without increasing the span, you put it on the outside face of the thumb hole (the top of the thumb).

Thumb Grip

The thumb hole itself can be modified to feel better. Several companies make inserts called thumb grips. You test the feel of the insert before it is placed into the ball to get the right shape and size for your thumb. The thumb hole is then drilled to fit the insert of which has the thumb hole that fits your thumb.

Thumb inserts are made of a hard smooth material. You can still put bowler's tape into the thumb insert, but generally you will need to adjust it a lot less because of it's better fit to your specific thumb.

Thumb Straights ®

This device is a molded piece of plastic or rubber material that is inserted into your thumb hole that forces the tip of your thumb away from the center of your bowling ball. It is very effective in making sure that you do not bend your thumb and it decreases the tendency of getting blisters on the back of your thumb. It enhances the release of your thumb straight out of the thumb hole, hence the name "Thumb Straigh ®t".

Sponge Thumb Inserts
There is an insert for the thumb hole that is not rigid, in fact it's made out of a spongy material. You put it on the back side face of your thumb hole. The thumb hole should feel very snug while the sponge is in use. The idea is to have the back of the hole give enough to allow for slight variations in swelling and contraction of your thumb and the size of the thumb hole itself. If you use the sponge type thumb insert, you may not need to use the Bowler's Tape quite as much because the sponge takes up the slack.

Thumb Slugs
Thumb slugs are solid cylindrical plastic inserts that are glued into a hole in the ball. The top is chopped off and then the correct size thumb hole is drilled into the thumb slug. The reason that thumb slugs are so successful is because of the design of multi-piece bowling balls today. One or more of the outer pieces may be sticky of rough depending on the materials used. That's not what you want for a nice smooth exit from the thumb hole.

The thumb slugs are primarily made out of two materials, urethane and vinyl. The urethane is the smoother of the two.

Adjustable Thumb Insert.
Vice Inserts Inc. makes an adjustable thumb insert. It rests on the back side of the thumb hole and has a small plastic screw in back of a plastic piece that rests against your thumb. Adjusting the screw makes the plastic piece move in or out to make the hole tighter or looser.

An adjustable thumb insert is allowed by ABC as long as it is made out of nonmetallic materials and nothing moves while the ball is rolling down the lane.

Exactacation of Your Thumb Hole.
Vice Inserts Inc. provides a process to pro shops that allows them to make an exact model of a thumb hole that you are satisfied with, and duplicate it exactly. A molding material is inserted into your bowling ball and is removed after hardening. A large hole is drilled into a new ball, the mold is inserted and the Exactacation material is poured into the hole around the mold. The result is a thumb hole that is exactly like the one you molded. And, the process can be repeated at any time for any ball.

Finger Grips.
Vice Inserts Inc. and several other companies make inserts that go into the finger holes of your bowling ball. There are a variety of shapes and styles.

By using finger grips, you get a better grasping power. They are by design not as slippery as regular bowling ball materials, so you get a better feel for the ball and can put more lift on the ball.

The grips need to be snug for the same reason as the thumb hole. As the weight of the ball is felt by your finger tips, your fingers will change shape, they will become more oval. So, oval shaped finger grips are used a lot.

Just as the your thumb expands and contracts, so do the fingers. You cannot put tape inside finger grips however, it won't stick. What you do is put tape in back of the grip between the backside of the hole and the finger grip. This tightens your finger grip enough to get an improved feel for your fingers during release and better lift on the ball.

Cleaning Your Bowling Ball

Several companies make liquids that clean your bowling ball very well. There are special ones for reactive resin bowling balls. You basically pour some on a cloth and wipe the ball with it.

The cleaners do a good job of cleaning off residue that may be "clogging" the porous surface balls. If you never clean the surface, you may not be getting the full potential of your bowling ball.

Be careful that you do not use any liquid that alters the hardness of the surface of the bowling ball. By ABC rule, any substance that can alter the surface is illegal at all times and ABC is considering a rule that will allow only a dry towel to be used during competition.

At present Isopropyl Alcohol and some other cleaning materials like "Simple Green ®" are allowed during competition.

Towelette Cleaners

One of the newer ball cleaning systems is a presaturated towelette in a resealable pouch. The towelette is large enough to easily clean a bowling ball and is simple and easy to use. You merely pull open the pouch seal, remove one of the towelettes out of the pouch and clean the ball by rubbing the towelette on the ball. The textured surface along with the presaturated cleaning agent, which appears to contain alcohol, cleans the ball very well. The key advantages to this cleaning system is that there is nothing to spill, you can stuff it into a very cramped bowling bag and it's legal to use during ABC sanctioned competition.

Polishing Your Bowling Ball

There is usually a bowling ball polishing machine in every bowling establishment. Generally, you polish only bowling balls that have a nonporous surface because the polishing machine buffs the ball with a fine bristle brush to remove dust particles, adds polish and the buffs again. The result is a bowling ball that is a lot shinier. The other result is that the surface porosity of the surface of the ball has been partially filled with polish.

The ball, after being polished, will probably curve less because it simply doesn't adhere to the lanes as much. It will also skid further down the lane before breaking.

Sanding the Surface of Your Bowling Ball

When a bowling ball has been used for many many games, it eventually becomes less effective. A pro shop can take your ball and lightly sand it with a fine sandpaper. The result will be that the grime and grit that had filled the surface pores are removed because they have been sanded away and a new porous surface has been exposed.

The ball now will break more and skid less.

Resurfacing Your Bowling Ball

When you have bowled for many many games and have scratched, dented and dinged your ball, it may need resurfacing.

A pro shop can take large grit sandpaper and take enough of the surface off to make the ball still usable. The pro shop then takes a small grit sandpaper and smooths the surface to give it the original porous characteristics. It's much cheaper than buying a new bowling ball.

Breaking in a New Bowling Ball

A New Bowling Ball
When you get a new bowling ball directly from the pro shop, it may seem to fit correctly in the pro shop. When you take that ball directly out to use in league play, you find that it just doesn't feel right. Through a process called "Exactacation" a thumb hole can be made almost exactly like the thumb hole of a previously drilled bowling ball. The Exactacation process is probably the best bet for taking a new ball directly from a pro shop and rolling that ball in league play.

Buying a New Bowling Ball
The best procedure to use when buying a new bowling ball is to give yourself plenty of time to purchase and test the ball before rolling it in league play. That means give yourself plenty of time to get the feel of the ball right before you ever leave the pro shop.

Usually a good pro shop will do an excellent job of measuring and drilling the ball. Your job as a purchaser of the ball is to be very frank with the pro shop about how the ball feels when you come to get the freshly drilled ball. A good pro shop will ask you to immediately go out onto the lanes and roll a game to check out the feel of the ball. If a problem is evident at that time, it can be fixed immediately. Good pro shops will work with you until you feel that the ball feels just right for you.

But maybe a week after that, the ball may not feel exactly right and the pro shop may not be open to get their help.

The following are various problems that can appear in a freshly drilled ball.

Thumb Hanging Up
The most frequent problem with a new ball is a thumb hole that is just not quite right. It just doesn't feel right. Very soon after you start practice, the ball hangs up on your thumb.

The most common problem with a new ball is simply a hole that is too tight. You should be able to insert your thumb into the ball without having to "force" it into the ball. You should be able to insert your thumb well past your first thumb joint, almost to your second joint. The further you can insert it, the better the feel will be.

If you cannot get your thumb into the ball as described, take a small round file and round the edge where your thumb rests on the ball. Bevel it so that it feels more comfortable. Make the leading edge of the thumb hole as comfortable as possible. There is a caution in doing this. Your thumb will fit better, but the span will be slightly decreased. But, usually, the difference is made up by your thumb being inserted further into the ball. Insertion of a piece of Bowlers Tape ® will solve the problem of a shortened span if it occurs.

If you don't have a vent hole, maybe you should consider one. Your thumb will still feel snug, but it will also release better because the vent hole will prevent a vacuum from being created below your thumb.

Some thumb slugs have a built-in vent hole. So, when you have a slug placed in your ball, you also add a vent hole. Vice Inserts Inc. makes a slug called an "Easy Slug" that has a vent hole built-in.

Hanging up can also be caused by bending your thumb toward the center of the ball; you're gripping the ball. When you do this, the back of your thumb is more like a point than a surface. That "point" will tend to stick rather than slide.

The ideal thumb orientation is when the end of the thumb is bent backward, away from the center of the ball making a "point" on the top of the thumb almost impossible.

To match the thumb being bent away from the center of the ball, the thumb hole must be ovaled to match the shape or your thumb. This combination gives the maximum surface of your thumb resting against the surface of the ball inside the thumb hole. If the thumb hole is the correct size and ovaling, no gripping is required to hold your thumb in place while you are delivering the ball.

Another possible solution to a hanging thumb is reverse pitch. If for some reason the new ball has the incorrect pitch, you will hang up when you try to release the ball. Too much forward pitch means that the thumb hole is angled too much toward the palm and fingers and you're having trouble getting your thumb to slide out.

Reverse pitch angles your thumb away from your palm and fingers.

The further you reverse pitch the thumb hole, the easier it will be to release the ball. **Caution: too much reverse pitch will cause the ball to release earlier than you want.** You will drop the ball. If you attempt the reverse pitch, do so a little at a time. You will usually need a tighter fitting hole when reverse pitch is used, but that too will make for a snug feeling thumb.

Unless you specified a forward or reverse pitch when you had the new ball drilled, they probably drilled it straight toward the center of the ball, zero pitch. The forward/reverse pitch is usually measured in 1/8ths. That means the thumb hole center has been shifted 1/8th of an inch at the surface of the bowling ball. The thumb hole can be pitched reverse as much as an inch depending on the ball drilling equipment, but anything over 1/8th inch is a big change from no reverse pitch at all.

Side pitch can also help you remedy hanging up on your thumb. Hold your hand out and look at your fingers and palm with respect to your thumb. Your thumb does not naturally point in the direction of your fingers and palm. It points outward a little and up toward the index finger. It's naturally in a handshake position. Rotate your hand and look at how the thumb is pointed.

In a relaxed position, free of the bowling ball with your palm facing down, your thumb usually points to the left.

If your bowling ball thumb hole has a little left side pitch, it will better match the relaxed position of your thumb. You may be able to release the ball easier because of the side pitched thumb hole.

In combination with the reverse pitch, a more natural thumb position is possible. It takes a fairly good pro shop to be able to get this correct. Side pitch is also measured in 1/8ths. Be conservative when you first try the side pitch; use only 1/8th left side pitch at first.

The objective of all of these different "pitching" scenarios is to relax your thumb. Some bowlers actually bowl without their thumbs in the ball. The rest of us try our best to prevent it from interfering as much as we can.

Release the Ball Early (Dropping the Ball)
The opposite problem is a thumb hole that fits too loose. And, either the thumb hole has too much reverse pitch causing the thumb to release too early, or the hole is simply too big or not ovaled right.

If you can solve the problem by placing bowling tape in the thumb hole, that's what you should probably do. It's actually a better combination to have your thumb hole fit very loose when you first get it from the pro shop with no tape at all. You can immediately add tape to make it a snug fit, then when your thumb expands or contracts, you can take tape out or add tape to get it right.

If you're reading and listening carefully, you should realize that a very loose fit is what you <u>should</u> have when you first get the ball if you intend to add tape before you first roll the ball. It gives you more flexibility in using the ball for more situations that will arise due to your changing physical constraints.

Another possibility is that your span is too short. You can easily check the span by placing your thumb fully into the bowling ball and then checking where the crease in your fingers line up with the edge of the gripping surface on the ball. For a conventional grip the second crease of the two gripping fingers should be beyond the edge of the gripping surface of the hole by at least 3/16" of an inch. More than 3/16" makes the grip feel looser. Less than 3/16" makes the ball feel tighter.

The same fitting applies to fingertip grips. The first crease of the finger should extend beyond the edge of the gripping surface by at least 3/16". And as before, less distance will promote a tighter grip and more distance will cause a looser grip.

Fingertip Grips Don't Seem to Fit Right
When your fingertip grips don't fit right, it can effect your average. The fingertip grips come in various styles. Some are ovaled more than others and some have a little bump on the inside face of the grip that give you something for your fingertip to push against. Other styles give you a rounder edge that may be more comfortable than a sharp edge.

If your fingertip grips just don't feel right. Make a slight change. Try a different style and maybe it will help you.

Changing fingertip grips doesn't necessarily involve redrilling the fingertip holes. The grips are glued into the holes and they can be removed. You should let a pro shop do it. It will probably only cost you the price of the new grips.

Go to a pro shop and ask to "feel" the alternative styles of fingertip grips. Find one that seems to feel better. Be sure that when you make a tentative choice, that you do so while putting a little pressure on the fingertips. Your fingertips will be compressed when the weight of your ball is on your fingertips.

Some fingertip grip material feels softer than others. Remember though that it's the feel of the fingertips as you release the ball that's important. The general rule for the feel during the release is that you should be able to feel the weight of the ball during the release.

The fingertip grips should be tight enough to pick up the ball by inserting your fingertips and lifting the ball (without using your thumb).

Have the pro shop switch the fingertip grips and test out the new ones. Don't get rid of the old ones yet. Make sure the new ones are acceptable in some practice. You can always have the pro shop reinsert the old ones if the new ones don't work out for you.

Lifting All You Can and the Ball Still Didn't Hook
You are cranking like a son-of-a-gun and the darn thing still won't break as much as you want and you don't want to buy another ball and you don't want to have it plugged and redrilled.

The overall break is influenced by many things. If you're lifting properly and it's still not breaking as much as you want and you don't want to have the ball plugged and redrilled, here's a quick fix. ABC allows one hole for weight distribution. It's called a balance hole.

A balance hole is usually drilled at the center of rotation of your ball. If you look at the rolling track on your ball, (the oil track), it's almost a circle. The center of that circle is the center of rotation. The balance hole is usually drilled at that center. It can be drilled on one side or the other for more or less side weight.

Since the more side weight you have, the greater the break is, drilling a balance hole to give you added side weight may solve the problem.

This is an easy solution because all you do is add a hole. It can be done in a matter of minutes by a good pro shop. After you have the hole added, make sure that the pro shop measures the weight distribution and does not exceed the limits of side weight (maximum one ounce). So, if you need that maximum one ounce side weight to make the ball work, do it.

Some balls have weird surface characteristics. Some hook more when their surface is smooth, some hook more when their surface is rough. Ask your pro shop which kind of surface effect ball you have and take the appropriate action. It's another easy and inexpensive remedy.

If you need to smoothen the surface, the pro shop can use a very fine sandpaper and smoothen the surface. If you need to roughen the surface, the pro shop can roughen the surface by using a course grade sandpaper.

As a last resort, you can have an additional hole drilled for your pinkie finger. Some pro's have added the pinkie finger to give additional lift and comfort.

Ball Hooks Too Much
You purchased more ball than you wanted. You roll the ball and it makes a hard left turn toward the 7 pin. As with the above case, you don't want to purchase another ball.

As you would think, a balance hole drilled to reduce the side weight might be a solution. The pro shop can drill the balance hole on the other side of the center of gravity near the initial axis of rotation to decrease the hook.

And, modifying the surface to get the proper surface characteristics is also possible. If the ball breaks more when rough, have it sanded smooth with a fine grit sandpaper. If it breaks more when it’s smooth, have it sanded with a rough grit sandpaper.

Testing Your Present Equipment

Recommended Bowling Ball Arsenal
If you expect to attain a 200+ average, you should have an arsenal of bowling balls to fit varying lane conditions.

You should have at least 3 bowling balls, a nonporous ball, a highly porous ball and a resin ball.

The nonporous ball can be very effective for right side spares, especially the 10 pin. It can also be used when the lanes get so dry that neither one of the other two balls can be used because they adhere to the lane too much. Plastic bowling balls work well in this case.

The highly porous ball can be used for average and high density oil conditions. This ball works well in the slightly crowned, crowned and blocked oil patterns. Particle Balls work well in this case.

The resin ball works well when the lane conditions are a little drier. The back end dryness seems to affect the hooking ability of the resin ball because of the surface effects. The ball tends to slide through any front end oil and adhere well at the back end, and adheres the best by the time it reaches the pocket.

Optionally, another choice is a bowling ball that combines the surface porosity with resin surface effects. This ball will handle heavy oil well and will drive through the pocket well. It can provide more hooking capability than the highly porous ball. It would replace the porous ball in your arsenal. Combined particle and reactive resin balls work well for this case.

Testing Your Bowling Ball Weight Distribution
Take your present bowling balls to a good pro shop and get them weighed. Most pro shops can measure the distribution of the weights for you.

Have the side weight, top weight, finger/thumb weight and surface hardness measured. Record the values and keep a copy in your bowling bag at all times to double check what is measured at any tournaments during check-in.

Most importantly, the measurements give you a basis of how you want your next bowling ball drilled in an attempt to change the rolling path characteristics and increase your average. The old saying “you don’t know where you’re going until you know where you’ve been” holds true.

Testing Which Ball has the Greater Hook in Oily Condition
If you have an arsenal of bowling balls, you need to at some point in time measure which ball hooks the most in very oily conditions. The winner will probably be the one with the most porosity, but the surface reactivity and weight distribution will affect it also.

At a time when the lanes have just been conditioned with lane oil, perform the “oily hook test”. Roll the ball with a path that rolls down the 20th board aiming mark. That’s where the maximum oil probably is. Make a note of where the ball end up on the left side. If the ball goes into the left gutter before going into the pit, estimate how far from the end it hit the gutter.

Test all of your bowling balls several times at the same position and you will determine which actually has the greater hooking power in very oily conditions.

For future reference, you will then know which will hook more. This test can help you make a choice of what ball to start with or what ball to switch to based on very oily conditions.

Testing Which Ball will Hook Less on Very Dry Conditions

A "dry hook test" can be performed on your bowling balls also. Usually, you would interested in which of your nonporous balls will hook less on very dry lanes.

Determine a time that corresponds to the driest possible lanes. There are some usual choices. How about after the late league the day that the lanes have been fully stripped. They should be "kind'a dry."

Roll the ball over an aiming mark board on the far right side. Choose one that is comfortable for you, one that you're not likely to dump it into the right gutter.

Roll each ball several times and make a note of where the ball ends up as it goes into the pit.

The results of the test will tell you which ball hooks less in very dry conditions. That will be valuable when choosing or switching to a nonporous ball for dry conditions and for shooting at right side spares.

Testing Your Bowling Ball Rolling Path Characteristics

Perform this test under different oil conditions, and try to match your league conditions as much as possible.

If you bowl in an early league just after the oil has been applied, test the balls with that condition. If you bowl in a late league after the oil has been dissipated, you need to test under those conditions. If you bowl in more than one league, under different conditions; perform the test under each of those conditions.

Have someone help you with this test. Your helper will concentrate on the rolling path characteristics and you will concentrate on rolling the ball normally.

Roll each ball and have your helper estimate how far down the lane the ball slides before beginning to break toward the pocket. Yes, it will be a really crude estimate.

Here's how to make it more accurate. Your assistant needs to be at a higher vantage point so that he may see when and where the ball begins to hook. Get permission from the desk and have your helper stand on the seat or some other high point. He must be out of your view and in no way distract any other bowler on the lanes.

The distance between the foul line and the head pin is 60 feet. The middle arrow aiming mark is about 15 feet from the foul line, so, it's about 1/4th of the distance. Half way is 30 feet and 3/4 is 45 feet.

So, your helper can simply write down 1/4, 1/2 or 3/4 for instance or you can try to write numerical values such as 15 feet, 30 feet or 45 feet.

Your helper can also note whether the ball enters at a steep angle or a shallow angle and whether or not the sideways rotation of the ball has stopped and the ball has “rolled out”.

The test will reveal which ball slides more before it hooks and the general hooking characteristics.

Preparing Your Bowling Balls for League Play

Why it is Important to Clean Your Ball on a Regular Basis ?
Each time you roll the ball, residue of some kind will be placed on the surface of the ball. If your ball has much porosity, it will begin to be filled up with "stuff" even with that first ball you roll. You should clean your ball on a regular basis.

Liquid Ball Cleaner in a Squeeze Bottle
As often as you desire, put some of the cleaner on a soft rag and thoroughly rub the cleaner onto the surface of the ball. Then take a soft clean rag and wipe off the cleaner and the dirt and grime that comes with it. Most of the dirt will come off with the first rag, but the second rag is important. Pay special attention to any places that have imbedded rub marks. In some cases you may need to take your fingernail and help the cleaner do that tougher job. Go through this process on one side of the ball and then the other even though the ball "usually" only rolls on one side.

After you have removed the excess cleaner and the grime, the surface should be "squeaky" clean. For a nonporous bowling ball you should be able to lightly rub your finger across the surface and hear a squeaking type of sound. That indicates a good cleaning job. For a very porous bowling ball, the squeaky sound is less noticeable. Make sure the track area of either type ball is clear of every unwanted marks.

Cleaning the Ball with the Ball Machine
Cleaning your ball is different from polishing your ball. Do not ever polish your ball unless you are specifically trying to change the surface characteristics of the ball. Ask the manager of the house you bowl in whether or not the ball machine the bowling center has applies polish or not.

Ball Polishing machines clean the ball somewhat and then add polish to the surface of the ball. The polish gets into the open pores on the surface of the bowling ball as well as add a very thin layer of polish to the entire surface. After applying polish, you will actually be rolling the ball on the polish instead of the surface of the ball. Gradually, the polish will wear away and you will again be rolling on the surface, but now the surface cracks and pores still have polish embedded in them. And finally the polish in those pores and cracks gets dislodged and you're back to where you started, and you will need to get it polished again to return the ball to it's former characteristics.

Hmmm . . . sounds like a good business doesn't it. A machine that bowlers need to continually return to and spend their money. I wonder why there are so many in the bowling centers? Hmmm . . . .

The question is whether or not you really want to do that. The best answer is that you should do whatever works best for you. If you've got an arsenal of bowling balls to choose from, you can switch to a smoother or a more porous bowling ball depending upon the needed rolling characteristic. If you don't have several bowling balls, polishing the surface of a bowling ball when you want to cut down on the gripping characteristics works pretty good. But, remember that the effect is only temporary and you need to watch for the changing rolling characteristics.

Ball cleaning machines merely buff the ball with brushes and cleaning buffing materials. They clean off most of the residue and do a fairly good job. You should, however, always check the ball carefully after the ball is cleaned by the machine. If some marks persist even after the ball cleaning machine, try the liquid cleaner and rub a little harder.

Your Arsenal of Bowling Balls

The Two Ball Arsenal
Ball #1 - A reactive resin ball that allows you to break back to the pocket under most lane conditions. The reactivity and drilling depends on what kind of trajectory you want the rolling path to have. This should be a ball that you have great success with at your bowing center at the time and lane conditions that you usually encounter.

Ball #2 - A smooth, non-reactive resin, non-static imbalance, hard surface spare ball. The characteristics of this ball should aid you in removing the effect that the lane conditions have in interfering with your spare making consistency.

The Third Ball
Ball #3 - A very dull or sanded surface reactive resin ball or a particle ball to use when the oil is very heavy. Because of the very heavy oil, you want the ball to start it's agonizing attempt to curve in the sea of oil as early as possible. The earlier the curve starts, the more the overall curve is likely to be. And the rougher the surface, the earlier the ball will "see" the surface of the lane and begin to curve inward.

The Fourth Ball
Ball #4 - A very smooth "pearl" subdued reactive resin ball or urethane ball that is drilled to delay long before the break begins for very dry overall conditions. In late leagues or in tournaments that have back to back squads without running the oil machine on the lanes, the lanes get very dry. A ball that delays it's energy release longer will have a better chance of staying to the right of the head pin. In addition to the long delay, the overall hook potential should be less than that of a ball you might use in an earlier league. You don't want the ball to have too much punch at the back end of the lane. You want just enough to get the ball back to the pocket under those very dry conditions.

The Fifth Ball
Ball #5 - A ball that you choose to use when the inside area is dry and the outside is wet, yuck! Since there are two very different ways to attempt to bowl with these lane conditions, there are two different ball design choices.

If you choose to roll the ball down and in on the wet outside boards, the caution of course is not to pull the ball onto the drier inside boards. Since you are in the oil and intend to stay in the oil, the overall break of the ball will depend on how far outside you release the ball. A non-reactive resin porous ball or a particle ball drilled so that the back end is tame is the answer. The porosity will help the ball break early and the tame back end will aid in preventing over hooking at the back ends.

If you choose to roll the ball completely in the dry area of the lane by starting on the left side of the dry area and angling the ball slightly to the right, the caution is not to swing the ball to the right. Since you intend to stay completely in the dry area, the delay of the break of the ball needs to be extremely long and it needs to break hard at the back end just before it impacts the pocket. A pearl reactive resin ball drilled to maximize the delay and the hook potential will satisfy those requirements.

The Straight Shot Ideal Spare Ball

The ideal straight shot spare ball should be as hard as possible, smooth as possible, a non-reactive surface and no imbalance in any direction. You want this ball not to interact with the lane in any way.

When you go to the pro shop and talk with the pro shop operator, tell him what you are going to use the ball for. It will not need to be an expensive bowling ball. It simply needs to have non-reactivity with the lanes.

The ball must be very comfortable. It must fit almost perfectly. Remember you are going to rely on that ball hopefully, very infrequently, but when you need it, you need to have the confidence about the feel of the ball in your hand. Take some extra time with the PBPSI Certified pro shop operator in getting the drilling just right for you.

Taking Equal Care of the “Spare” Ball

That second ball in your arsenal, the spare ball, needs your care and attention also. Make sure that it is inspected, cleaned and stored properly, just as your strike ball is.

Clean it often, but you should never have to do anything else to the surface of the ball. If it becomes dinged a little too much in the rolling track area, either get it resurfaced or get a new ball. If you’re gonna play, you gotta pay.

The Technical Section

This is a little technical from here to the end of this issue, but it's good reading material to really learn how a bowling ball works. And you will not have a pop test after you have read it. Your homework, however, is to check some of it out. Find out what the basic technical parameters are for the bowling balls that you own.

The key to being a really high average bowler is to find out what set of bowling ball specifications work best for you. If you have a ball that really works well for you, be sure that you find out what the specifications are for that ball. Apparently it's a good match for the manner in which you release the ball and the conditions that you usually are accustomed to.

The Relationship between the Radius of Gyration and the Rotational Velocity that You are Able to Impart to a Bowling Ball

What difference does it make whether a bowling ball has a high or low radius of gyration? (We are only considering balls that weigh exactly the same, 16 pounds for example. So, the only variable is how that mass is distributed inside the ball to increase or decrease the Radius of Gyration).

Remember that rotational mass has the property called mass moment of inertia, the property that says that the rotational mass does not like it's rotational velocity changed, you have to apply a torque to get it to change. (Newton's Law expressed for a rotational mass).

T = J * a (Torque (T) applied equals the rotational mass (J) times the rotational acceleration (a) of the mass).

Okay you've got a choice of rolling a low mass moment of inertia bowling ball (low radius of gyration) or a high mass moment of inertia bowling ball (high radius of gyration). Remember that for the same weight bowling ball, the higher the mass moment of inertia is and the greater the radius of gyration is.

But J is directly proportional to the Torque applied. Assuming that you are able to apply the same exact torque to each one of the two bowling balls, one with a high J value and one with a low J value, what happens? The bowling ball inertial rolling characteristics are best seen by looking at the rotational mass version of Newton's Law.

Look at the equation in a different way, defining the acceleration "a" in terms of T and J,

a=T/J
(Torque (T) applied equals the rotational mass (J) times the rotational acceleration (a) of the mass)

For the same T applied (which is what you do when you impart energy into a bowling ball), if you increase J, you decrease a. So, for the same torque applied the higher J ball will have a smaller initial rotational velocity (higher rev rate). And, correspondingly the ball with the lower J value will have a higher initial rotational velocity (higher rev rate).

So a smaller J value lets you "rev" the ball more initially. You get a higher rev rate on the ball for the same applied torque (lift) during the release of the ball (you are able to accelerate the ball from zero rotational velocity to a higher rotational velocity). And you get a lower rev rate on the ball with higher J values (you are restrained from accelerating the ball to a higher rev rate because of the higher RG value).

New Surface Exposed

One of the attributes of low RG balls that is directly related to the increase in rev rate over the high RG balls is more surface of the ball is exposed to the lane as the ball changes it's axis of rotation toward the "unhooked" state.

After you release the ball, the location of the track is constantly changing until that final unhooked state. As the location of the track changes, the ball is constantly exposing new surface of the ball to the surface of the lane. The lane condition that matches that attribute is wet lanes. If you have two bowling balls with exactly the same design parameters except that one has a lower RG value, the ball with the lower RG value will hook more because it exposes more fresh surface that has not encountered the oil. The low RG balls will tend to have a "snap hook" ball path shape (a hockey stick shape).

In the opposite sense, bowling balls with high RG values will rev less and expose less fresh surface to the lane surface. They will hook less and so considering all other parameters constant, the high RG ball will work better on dry lanes. The high RG balls will tend to have a "banana" ball path shape.

Unhooking the Ball

One of the questions that has very gradually materialized over the years is that of whether or not the ball should keep trying to hook constantly throughout the entire roll of the ball or should it finish hooking and straighten out as it gets close to the pocket.

The more basic question however is "What does the bowling ball want to do?" Here's an answer to the more basic question first. Imagine that a bowling ball is absolutely clear and has a weight block inside the ball that is a tall cylindrical shape. Remember that the weight block is one of the heavy parts of the ball and contributes appreciably to the rotational inertial effects of the ball.

There are two very stable but different preferred axes of rotation that the ball can flare toward. One is the axis that is at the center of the cylindrical weight block.

The other axis that is preferred by the ball is the axis that is midway along the length of the cylinder running through the side of the cylinder. This axis of rotation has a higher mass moment of inertia and thus has a greater tendency to keep rotating with the same rotational velocity. It has more "driving power" through the pin deck area because it has a greater mass moment of inertia. Bowling balls that are drilled so that they flare to the maximum mass moment of inertia axis of rotation are "leverage drilled."

The reason you hook a bowling ball is so that you can get ample angle of attack into the pocket. Once you have reached that desired angle of attack, there's no need for the ball to hook any longer. In fact you would do better not to hook it anymore than it takes to get the proper angle of attack.

The trick is to get the ball to the pocket at precisely the desired angle of attack. If, just before the ball enters the pocket (i.e. impacts the head pin) the ball has reached it's final rotational track, and the axis of rotation for that track is the leverage axis, the ball is entering the pocket at the correct angle of attack and the maximum mass moment of inertia. It is the creme-de-la-creme of all possible strikes.

So, ideally you want to complete the hook process an instant before it impacts the head pin.

Bowling Balls with Mass Bias
Mass bias is created when the weight block is not centered in the ball or is designed with an extra mass at the side. If the weight block of our model is not exactly cylindrical and has a bulge in the middle and the weight block is tilted over to one side, the point on the surface of the ball that is usually closest to the bulge is called the Mass Bias Point.

Differential of Radius of Gyration
Radius of Gyration is measured with respect to the "Z" axis which is defined as the direction the Pin points outward from the surface of the ball from the center of the ball.

The two other directions are perpendicular to that direction and the Radius of Gyration for those two axes can also be measured. The difference between the Radius of Gyration measured at any two of the axes is defined as a Differential Radius of Gyration. The largest is specified as the DRG of the ball.

The Effect of High Differential Radius of Gyration
The effect most realized when a ball has a high differential radius of gyration is start flaring quicker and stronger. The total flaring distance is longer.

A Detailed Look at Friction, Texture Traction and Reactive Resin Micro Friction

The Friction and Traction Model
A bowling ball surface when looked at through a microscope has a very irregular surface. There are little peaks and valley's associated with the surface. The smoother the surface, the smaller the peaks are and the less deep the valley's are. You cannot get a bowling ball that doesn't have this peak and valley characteristic. It's just the way things are.

Friction vs. Traction Definitions
Friction of bowling balls can be defined as the matching up of the peaks and valley's of the ball surface and the peaks and valley's of the lane surface on a dry lane surface. The better the peaks and valley's match up, the higher the friction is between the ball surface and the lane surface. The peaks and valleys are rubbing across each other in a smooth continuous motion, so the peaks and valleys are very very small.

Traction is the ability of the ball to protrude through the lane dressing so that there is some amount of mechanical rubbing of the peaks of the bowling ball with the peaks of the lane surface. The greater the rubbing of the peaks, the greater the traction. The effect on the ball is the same. It causes the ball to release energy and break across the lane surface.

Note that what works well in heavy oil conditions does not necessarily work well in dry conditions. High peaks in the surface of a bowling ball works well in the oil, but when the ball rolls out of the oil, the surface is actually making less contact with the lane surface and may in fact have much less friction than a smooth surface ball. It's peaks are preventing the ball from rubbing with enough peaks of the lane surface to create high friction. Consequently, the ball may curve less when the ball is sanded more.

So, there is a limit to how rough you can sand a ball.

The Two Kinds of Friction
There are two kinds of friction, static and dynamic. When two surfaces are sat on one another and then one is rubbed against the other, it takes a certain amount of force to get the sliding to occur. That type of friction is called static friction. Once the sliding begins, there is less friction. That's called dynamic friction.

For bowling balls that work on a friction rather than a traction basis, the friction is almost all dynamic friction. While the ball is rotating faster than it is speeding down the lane, the ball is slipping and dynamic friction is the rule. When however, the ball energy is depleted and no longer rotating faster than it is moving down the lane, not slipping, the ball still rolls, it is static friction that is the rule. The slipping ball has the opposing peaks and valley's of the ball and the lane surface rubbing against other (slipping as the ball rotates faster than the speed of the ball). When the bowling ball energy is depleted, the peaks and valley's do not rub against each other; they simply intermix and there is no relative motion of the ball with respect to the lane surface. The point (or very small area) on the ball that touches the lane surface does not move with respect to the lane surface that it rests on at that instant. It's surface velocity with respect to the lane surface at the point of contact is zero.

The Battle between Friction, Texture Traction and Reactive Resin Micro-Friction
Friction and texture traction have been around for many years and are still used today by many high average bowlers to control the initial friction characteristics of the bowling ball.

Texture traction is basically the sanding circles tread effect that occurs when the ball is sanded in a preferential direction. The peaks and valleys of the surface microstructure are larger and a lot smaller in number than for normal friction. The peaks of the ball and the peaks of the lane surface tend to bang against one another and cause the ball to rotate, hence dues to roughness, traction is better in the oily part of the lane. Because the grit of the sandpaper gouges out ball surface material, the effect is that similar to the tread on an automobile tire. Usually the sanding circles are located so that they are crossing the oil tracks of the ball. And, in the same way that snow tires and rain tires with relatively new tread give you excellent traction, the ball that has the sanding circles across the oil tracks on the surface of the ball will have better traction.

Friction is the resistance felt by the ball surface when the smooth rubbing of the ball and the lane surface interact. The peaks and valleys of the microstructure of the surface is are very small compared to texture traction. You would have to zoom in with a microscope compared to the texture traction surface. The principals are basically the same; they just act on a much smaller scale. Since the peaks and valleys are much smaller and there are a lot more of them, the effect still tries to rotate the ball. And if tiny size of the peaks and valleys of the ball surface match up fairly well with the size of the peaks and valleys of the lane surface, the total friction is maximized. That's why some balls work better on some lane surfaces and others don't.

Reactive Resin Micro Friction works in a different way. It relies on the getting the most contact between the surface of the ball and the surface of the lane. Generally, the smoother the surface of the ball, the more reactive resin micro friction there will be between the two surfaces. Obviously the ball with the smooth surface will not adhere well in the oily front end part of the lane. But, it will react better in the drier part at the backend of the lane. For reactive resin, it's a lot better.

In the reactive resin micro friction process, the surface of the ball, as it ribs against the lane surface, changes its friction characteristic. It becomes a little softer than for other type bowling balls. When you sit a bowling ball down on a lane surface, the point where it sits is not a point exactly; it's more like a circle. That circle is the footprint of the ball. The size of the footprint is proportional to the hardness of the ball. The same thing happens while the ball is rolling down the lane surface. The difference for reactive resin surfaces is that during the time that a specific spot on the ball is in contact with the surface, the material that is in contact with the ball gets a little softer and thus exhibits more friction. (A soft marshmallow rubbing against a lane surface exhibits more friction than a smooth hard glass paperweight does).

Particle balls are designed to perform their resistance duties as a form of texture traction. The little particles that stick out of the surface act as the taller peaks in the texture traction balls. It is the the number, stiffness and the size of the particles that determine how the ball reacts in the different parts of the lane surface.

The fewer the number of particles, the more the ball can exhibit friction characteristics at the back end of the lane. The greater the number of particles, the more the texture traction effect will be felt.

The smaller the size of the particles, the less the particles will interfere with the friction at the back end of the lane. The larger the particles, the greater texture traction the ball will use while still in the oil on the lane surface.

The harder the particles, the more the particles will exhibit the texture traction effect while the ball is still in the oil. The softer the particles, the less the particles will interfere with the friction effects at the back end of the lane surface.

Some balls are now a combination of reactive resin and particle balls in the attempt to get the maximum amount of overall friction, texture traction and reactive resin micro friction effects possible.

The Hardness of the Surface of a Bowling Ball

The hardness of the surface of a bowling ball effects the friction of the ball against the surface of the lane in a big way. Let's say for example that you built a steel surface bowling ball and one that is made of clay. And further, the balls have about the same size peaks and valley's as the lane surface. The steel is very hard and the clay is very soft. Because the steel is very hard, the intermixing of the steel surface peaks with the peaks of the lane surface is a very small circle as it sits on the lane surface. The clay bowling ball has a much larger footprint on the lane surface. Because it is soft, there is more of the clay surface peaks and valley's inter-mixing with the peaks and valley's of the lane surface.

Thus the softer the surface of a bowling ball, the more friction it can exhibit because it simply is rubbing against a larger area on the lane surface, a larger footprint. That's why ABC limits the hardness to no lower than a 72 rating on the durometer "D" scale.

The Hardness of the Inner Core of the Bowling Ball (Repeated here for clarity)

Some bowling balls have a super hard inner core. The newest balls have either a ceramic or a titanium inner core. It is very lightweight, so it doesn't add that much weight to the ball and it is extremely hard, so it doesn't deform very much when impacted or when it impacts something else (like a pin for example).

Damping is the primary effect that is changed by the super hard core. The less spongy the core is, the less it absorbs impacts. Ceramic and Titanium are less spongy than normal core material. Because the inner core absorbs shocks less easily, the energy loss in an impact is less. That means that the total energy available after each impact is a greater percentage.

When a bowling ball impacts a pin, both the pin and the ball are affected. If there is a sound made during the impact, and there always is, the energy to make that sound is taken away from the available kinetic energy of the ball. If the ball becomes deformed during the impact, and it always does, the internal materials are very slightly heated up. The creation of a slightly hotter bowling ball results in still more energy taken away from the kinetic energy of the bowl-ing ball. The parameter that ABC specifies for governing the design of bowling balls with respect to their energy loss due to impacts is called the Coefficient of Restitution.

The limits that ABC specifies for the Coefficient of Restitution is between .65 and .78 . A ball that has a higher Coefficient of Restitution loses less energy during the impacts with the pins. A harder central core, like ceramic or titanium tends to make the ball have a Coefficient of Restitution at the higher end of the range of values that are legal, closer to the .78 value.

As a bowling ball travels through a rack of pins, each impact that the ball make with the pins releases some of the energy of the ball into the impacted pins. So, after the first impact, the ball has a little less energy and it slows down. After the second impact the ball has even less energy and it slows down further. Successive impacts causes the ball to go slower and slower. You cannot design a ball that doesn't release part of it's energy at the impacts.

The trick is to design a ball that loses less energy at the impacts due to acoustical and thermal effects. Thermal and acoustical effects have nothing to do with knocking down the remaining pins. The trick is to retain as much of the kinetic energy of the ball as possible.

If the ball is going to lose energy as it travels through the pins, and it always will, the higher Coefficient of Restitution ball will have more kinetic energy left after each succeeding impact.

Heh, every little bit helps!

Temperature Effects on Friction

As the temperature of a bowling ball increases, the hardness decreases. For example, if you live in Las Vegas and you bowling in a summer league, you don't want to leave your bowling ball in the trunk of the car for too very long. It might be a little less round than is was before and the ball may break a lot harder across the lane surface during the early part of the first game.

And for the same reason, if you live in Alaska, you might want to make sure that you keep your bowling ball in a warm room the night before you bowl. If you do not, both the gripping may be tighter and the surface will have less friction.

Not doing anything that changes the surface of the ball is the key. During the process of "weighing in" just before a PBA tournament, one of the measurements that PBA officials take is the hardness measurement. After the ball is checked and it passes, the PBA member is allowed to roll the ball in competition as long as they don't do anything to change the surface of the ball. But many times, a ball may not pass the hardness test when it is measured. If the hardness is right below the lower limit, the PBA member is told to place the ball in a cold area for a short period of time and come back and check the hardness again.

Friction Change Due to Oil Absorption

A bowling ball surface is not completely solid. They all have some amount of porosity. That means that the minute pieces of material that make up the coverstock are not exactly pressing against one another. There is some amount of space between the microscopic pieces. The more loosely the pieces are tied together, the greater the porosity and the larger the spaces are between the pieces of material that make up the ball coverstock.

All bowling balls will soak up oil to some degree. Plastic balls soak up the least, then urethane, reactive resin and particle balls in that order of increased ability of soaking up the oil. The soaked up oil affects some balls differently than others.

Since plastic balls soak up the least oil, the least effect is noticed. And the effect is predictable. the plastic ball hooks even less because of the imbedded oil.

Urethane balls soak a little more and reactive resin balls still more and finally the particle balls. There is a big difference between the oil penetration into a particle ball and of the other bowling balls. They are generally the most porous bowling balls because of the mere fact that their coverstock is by design made of a mixture of a great amount of soft particles and a specified number of hard particles. The mixture, if those hard particles are large and a high percentage of the mixture, cause some particles balls to act like a sponge as they roll through the heavy oil.

A Clean Bowling Ball and Friction
Regardless of the type of ball, as the oil is soaked up by the ball, it has less friction. That oil that is in the porosity of the ball is very near the surface of the ball. If you don't wipe off the ball after every single roll of the ball, it just accumulates right there. And if there is oil that has accumulated at the surface, the rubbing action of the little peaks and valley's of the bowling ball against the surface of the lane tend to rub less and slip more (decreased friction). The valleys are filled in with oil.

The type and cleanliness of the towel that you wipe the ball off with does make a difference. If you simply store a bowling towel in the bowling bag and hardly ever clean it, it will get very oily and the purpose of cleaning the ball will be defeated because you will only add or simply push around the oil that is on the surface of the ball. A relatively soft towel probably works the best and is the most cost effective. A soft towel will get closer to the surface of the ball than a towel that has a harder stiffer material. One of the best towels available is the the new microfiber towel. It has tiny fibers that stick out of the surface of the towel material. Those tiny fibers help draw the oil out of the ball as you wipe the towel over the ball.

Regardless of the type of towel, it needs to be cleaned on a regular basis. The best of situations is to have one clean towel for each league that you bowl. That means that each time you start off with a clean towel. The microfiber towels are relatively small, so you can stuff several into a bowling bag. But each time you use a towel, it must be taken home and washed. The more regularly you clean the bowling towel that you use, the more the bowling ball will retain it's expected friction and traction with the lane surface.

Cleaning the Bowling Ball before Competition
Bowling balls should be deep cleaned on a regular basis with very strong cleaner. Cleaning the ball just with a towel is simply not enough. I recommend that it be cleaned just before you leave for the bowling center with the strongest cleaner you normally utilize. Generic fingernail polish remover works quite adequately. You cannot use it after any sanctioned competition begins or after the ball check-in process is completed.

Chemical Effects on Friction
Some ball cleaners have very potent cleaning agents as part of their overall solution. Those cleaning agents do clean very well, but they also change the surface of the bowling ball. They tend to make the surface softer. That's why very few ball cleaners are approved for usage during ABC competition. You can use just about anything before competition, but after competition starts, you are limited to a select few ball cleaners. Isopropyl alcohol and Simple Green are two of the popular ones.

One of the best cleaners is pure acetone. It is very flammable however and it does soften the surface of the ball. It's one of those cleaners that are not allowed after competition begins. Fingernail polish remover has a small amount of acetone in it. It cleans reasonably well and is relatively inexpensive. Just the generic fingernail polish remover is adequate; you don't need the special additives to make it smell good or stuff like that.

Many years ago one of the PBA members found that if he soaked his bowling ball is a special chemical (I believe it was methyl ethyl ketone, also very flammable), it became much softer and thus hooked more. At that time there was no hardness specification so it was completely legal. Now those "soakers" are not allowed and MEK is banned for use on bowling balls.

Leaching a Bowling Ball

Another example of how temperature affects a bowling ball is the process of "leaching" the oil out of the surface of a bowling ball. There are several machines that automatically heat the ball and rotate the ball at the same time and allow the oil imbedded in the surface of a bowling ball to be extruded and deposited into a pan. The heat applied to the ball surface opens up the porosity of the ball surface and allows the oil to seep out. It had been drawn into the surface by capillary action at the surface of the ball.

Somehow bowlers have gotten the idea that just applying heat and not rotating the ball constantly is okay. There are several common methods used. One very unacceptable one is to stick the bowling ball in an oven for a few minutes. Generally, the heat is too hot and the ball is not rotating at all. And as you would expect, when the ball is removed from the oven, the bowler doesn't know it, but the ball is not round anymore. It is now and egg shape usually with the imprint of a grill on one location of the ball.

Another method is to sit the ball under a small lamp and let a 60 watt bulb about 12 inches away and heat the surface to draw the oil to the surface. The ball must be rotated about every 15 minutes or so. This method is marginally okay but is very dependent upon the operator to turn that bowl every 15 minutes and not forget that task. Just before rotating the ball 90 degrees, the oil that has made it's way out of the surface should be wiped off the surface.

Still another method involves giving the ball a nice hot bath. Fill the bath tub with really hot water (you ought to wear gloves when you do this; you don't want to either burn your hands or drop the ball when putting it in or taking it out). Place the ball in the hot water completely submerged. A good solution of some liquid detergent added to the hot water while the tub is being filled might make the leaching a little easier. It's not necessary for bubbles to be present, there just needs to be a very soluble water solution. After leaving the ball in the hot water solution for some extended length of time (about an hour in some cases) most of the oil had been released by the ball coverstock and is now at the surface of the water. Yuck! It's really a mess. I hope you have some of that foaming bathroom cleaning stuff. You're going to need it. But, it does do a reasonably good job and is not too abrasive to the shape of the ball. You do have to let the ball dry out before using it though.

Of all of the methods discussed above the bath tub method results in less deformation of the ball surface and does a good job of leaching the oil out of the ball surface. The problem is that any tape you have in the ball has to be replaced. So, for that reason, I do not recommend it.

It's important that you don't do anything to cause the ball to go out of round. An egg shaped bowling ball simply will not drive as hard (less friction) as round shaped bowling ball.

The Roundness Effects on Friction

A round shaped bowling ball has greater friction than an egg shaped bowling ball. The more egg shaped a bowling ball is, the more it is liable to become airborne as it rotates from the skinny side to the fat side of the egg.

At least once a year, every bowling ball that is utilized repeatedly in leagues and tournaments should be resurfaced. The resurfacing makes the bowling ball spherical again. That's a good thing. Spherical shaped bowling balls retain contact with the surface better, hence greater friction.

The Other Reason Why Bowling Balls Need to be Resurfaced
The manufacturers are not dumb. They hardly ever make a ball that will last a long time. The friction mechanisms mentioned above cause the area where the ball rolls to become "tracked out." It becomes worn in that area, more flatter than the surrounding area.

The more revs you impart to the ball, the quicker it will wear away the surface. Some professionals will only use a ball for a very few games and then drill a new one.

Well . . . aren't they the lucky ones.

The Lane Topography Effects on Friction
The topography of a lane surface is basically how the surface tilts one way or the other, ie the levelness of the lane. ABC specifies that at no location on the lane surface can there be more than 40 thousandths of an inch down or up with respect to a horizontal lane surface. Many years ago, the personnel that resurfaced wood lane beds would intentionally place a 40 thousanths inch depression at either the 2nd or 3rd arrow depending upon the wishes of the responsible person at the bowling center. The ideal location in those cases was to roll the ball right down that depression. It kind'a guided the ball until the ball came out of the oil. But they don't do that now . . . .

Even a synthetic lane bed can be unlevel. There are good kinds and bad kinds. The bad kind of unlevelness is when the outside tilts down. That means when you roll an errant ball to the outside, it becomes airborne just enough to make it probably go into that wide 3 1/2 inch deep depression to the right of the lane. The effect is that the ball gets a lot less friction because its actually in the air some of the time and the rest of the time its trying to go up hill to get back to the pocket (remember the last time you walked up a steep hill).

The good kind is similar to the situation mentioned for wood lane beds. If the outsides are tilted up, but still within the legal limits, an errant ball will face a much higher friction caused by the up hill nature of the lanes surface as the ball travels farther and farther to the outside.

So, it's not just the great oil and the oil patterns that aid the bowler in scoring larger scores, its the topography of the lane itself.

Where the Rubber Meets the Road
The friction/traction effects are much like that of automobile tires. There are specialized tires for different road conditions. Snow tires for example are designed for maximum traction. They have little spikes or hard particles that stick out of the surface of the tire to get that traction effect (sounds like a particle ball to me). The drawback of having snow tires on a vehicle is that because of the high traction, they reduce the gas mileage. So what some people will do is switch back to regular tires when the weather gets better and the high traction effect is not needed.

Regular tires have a combination of traction and friction. The actual surface of the rubber is a high friction surface. The edges of the tread cause a traction effect when the tires encounter any effect that the flat friction surface cannot handle. The effect is more pronounced when the tires are turned, but the effect is always there to some degree.

The higher the air pressure you have in your tires, the less the friction and traction the car has. And because there is less friction, the car get more gas mileage but I doubt if the trade-off is worth the safety factor.

The other end of the scale is racing slicks at the drag races. You will probably remember the cars preparing the tires for a race just before the race begins. They get the tires extremely hot and “soft” by literally “burning rubber” for a few seconds at the start of the track. The preparation yields two tires that have a greatly increased friction and traction due to the temperature and softness of the tires and the fact that a coating of that soft and hot material now is on the surface of the track where they are about to race. If the tires have not been “smoked” enough, the car will not get enough friction and traction and the car will not accelerate correctly at the beginning. Smoking the tires at the beginning of the race is not a good thing if they are not getting enough adherence to the track surface.

Bowling balls act in the same manner. The high density (highly loaded) particle balls are like the snow tires. The combination particle or lightly loaded designed particle balls or the combination particle and reactive resin balls act like the normal street tires. Pure smooth surface reactive resin balls act like the racing slicks at the drag races (once the dry part of the lane is encountered).

High density particle balls are designed to adhere to the lane surface as early as possible. The basic concept is to have those particles protruding through the heavy oil making contact with the lane surface.

Somewhat reduced density of the particles combined with a reactive resin surface offer a little farther adherence down the lane and a high adherence at the backend of the lane.

Smooth reactive resin balls will slide considerably in the oil but exhibit very high friction at the backend.

Bowling Ball Technical Specifications

The Manufacturers Stretch the Truth
Each ball manufacturer has their own scale for how they state how much their ball will react on the lane surface. They all were once on a scale of 1 to 10. Now some are 1 to 10, 1 to 20, 1 to 100 etc.

The magazine "Bowling This Month" is the standard that most people utilize for getting a little more credible information about a ball. But their evaluation is somewhat limited in the fact that each ball is tested with only one type drilling layout.

So, how are you going to accurately choose a ball based on the manufacturer information? And, what are the most basic parameters that you can rely on to give you credible information?

And Now the Final Dumb Thing
In the past few years the manufacturers have changed scales for their own data. So now a rating listed for a ball a previous year for example isn't even measured on the same scale as the one produced this year.

The Secret Ball Rating Evaluation System
Actually, I've penetrated the highly secret security of several of the ball manufacturers facilities and I did find one thing in common. All of the successful ball designers have an imaginary 7 foot tall white rabbit named Harvey that is their best friend. After visiting a few of the facilities, I realized that Harvey was the one doing all of the evaluations and was responsible for the ratings.

He's a fairly good bowler, kind'a hard to drill a ball for correctly though.

Bowling Ball Ratings Supplied by Manufacturers (Fudgable Numbers)
The Hook Potential
This rating is a number related to how much the ball could possibly hook.

The Length Potential
This rating is a number related to how long the ball will travel down the lane before it begins to hook across the lane.

Back End Potential
This rating is a number related to how aggressive the ball is on the back end compared to the front end of the lane surface.

Flare Potential
This rating is a number related to how far the ball may flare around the surface of the ball.

Ball Manufacturer Real Numbers
These are real numbers, not some evaluation by some 7 foot tall white rabbit with a bad fitting ball.

RG - Radius of Gyration
This parameter is related to how much of the mass of the ball is toward the surface of the ball.

The higher the RG, the greater the percentage of the mass is located farther away from the center of the ball. Since the RG is measured about three axes X, Y and Z, there are three RG values. The average RG is usually what is listed, but usually stated in some easier to read scale.

Remember, low RG balls are easier to rev up to a high rotational energy state and just as easily release their rotational energy quickly. Your hand inputs the energy and the dry lane at the back end takes it away as the ball breaks toward the pocket.

DRG - Differential Radius of Gyration
This parameter is related to the shape of the total mass distribution inside a bowling ball. It is mostly related to the shape of the weight block. The highest difference between the RG values is what's generally stated as the DRG for a bowling ball. It is also usually stated in an easier to read scale.

Remember that the DRG is directly proportional to the flare distance, The higher the DRG, the higher the flare distance.

Grit Number - Surface Texture Roughness
This number is usually the out of box surface texture that the ball was processed to at the final stage before packing. The Grit Number is an inversely stated number. The higher the number is, the smoother the surface is. So, a 400 grit is much rougher than 2000 grit surface.

So, What are the Bowling Ball Design Characteristics to Look For?
The greater the reactive surface usually is, the greater the listed hook potential is.

The softer the surface, the greater the hook potential is.

The greater the porosity (and Coefficient of Friction), the greater the ball will hook early in the roll of the ball.

The lower the Radius of Gyration, the easier you will be able to "rev" the ball up to a higher rotational velocity, but the easier it will spin down after it comes off the front end oil. The lower RG ball will be more "snappy".

The higher the Radius of Gyration, the harder you will be able to "rev" the ball up, but the ball will maintain the rotational velocity longer in the roll of the ball. The higher RG ball will be more "arcy."

The greater the Differential Radius of Gyration, the greater the flaring distance is on the surface of the ball.

The harder the central core of the ball, the higher the Coefficient of Restitution will be and correspondingly, the more energy will be available to be imparted to the pins by the ball.

The Borden Number

Snappy versus Arcy

The most basic of all choices that a bowler will make about a bowling ball is the shape of the ball path. Some bowlers want a ball that has a nice “arc” to it, a banana type ball path shape. Other bowlers want a “snap hook” type ball path shape similar to a hockey stick. It is mostly a mental comfort thing.

Generally, the snap hook path is better for reserving energy for the impact with the pins but is less controllable. The arc ball path is more controllable but generally eats up more energy earlier in the path of the ball.

The three real number parameters RG, DRG and Grit Number can be used to form a number that is related to how snappy the ball is. It’s called The Borden Number.

It’s a number that can be used to compare bowling balls of the same manufacturer or different manufacturers because, it only uses real numbers that describe the bowling balls. The best results come from comparing balls of the same type and manufacturer.

Note that the number does not relate in any way to how the ball was drilled, who tested it, what the lane conditions were, how fast the ball was rolled or what the rev rate of the release was. (Most and sometimes all of those parameters are mysteriously missing in the manufacturers and the ratings by the magazines. . . . therefore they probably did use a 7 foot tall white rabbit to test the balls).

Is the Borden Number exact? No. Very few things are exact these days. But it’s very useful in comparing two possible choices for a bowling ball purchase. If they are about the same type of ball, the one with the highest Borden Number will most likely be the snappiest.

The Borden Number

The Borden Number is defined as BN = Grit * DRG / RG
(BN = Grit multiplied by the DRG and then divided by the RG)

As the Grit Number increases, the smoothness of the ball increases which aids the ball in getting farther down the lane and thereby increasing the distance before the ball reacts to the drier lane surface. So, as the Grit Number increases, BN increases.

As the DRG increases, the Flare Distance increases which aids the ball in being able to still flare after it is in the drier end portion of the lane surface. So, as the DRG increases, BN increases.

As the RG increases, the ability to rev up the ball as well as the ability of the ball to release it’s energy quickly is decreased. (Higher RG react slower to the surface). Hence, as RG increases, the BN decreases.

So, you can classify all balls with this number because it is a real number.

But most importantly, you can take any two balls and compare their Borden Numbers. The one that is the highest will most likely tend to snap more. Old ball, new balls, it doesn’t make a difference, you can still compare the Borden Numbers.

Yes, A Bowling Ball Has Mind of Its Own

What the Ball is Really Designed to Do
What the Borden Number really states is something about what the ball really is designed to do. And, since the most basic of all design criteria is the "snappiness", it works fairly well.

It should be obvious at this point . . . .

Well . . . maybe not.

Okay, back to the beginning.

Once upon a time in a galaxy far far away, there once was a planet inhabited by a very advanced civilization of 7 foot tall white rabbits. They really enjoyed bowling. They had much the same system of bowling that we have here with one exception. They only had one type of bowling ball and one specific lane condition and lane surface. Did I mention that the bowling ball could only be drilled using one specific layout.

Basically everybody performed on the same playing field with the same equipment. It was fantastic competition and everyone really worked hard to score well and to maintain a high average. It was an average based on knowledge and skill rather than financial ability to purchase an arsenal of bowling balls.

Did I mention each bowler (7 foot tall white rabbit) was limited to one ball per decade. For that reason, they really took care of their bowling balls.

Well, in the far outback of the wilderness came a bowler named Harvey. He was never satisfied with the situation on the planet. He always wanted to do this or do that to a bowling ball and he had lots of ideas on how to change the weight block inside a ball to make the ball react differently and the cover on the outside to make it break across more and more of the lane surface.

Eventually he was banned from the planet. At some point in time he arrived on the planet Earth. After a short period in the movie industry (I understand he had a drinking problem), he confronted the bowling ball manufacturers with his ideas.

They all loved his ideas and secretly hired him to do all of their ball evaluations.

Now get ready. The following facts have never been revealed up until now.

Harvey is left handed . . . and besides that, he has a vision problem. I understand it's from eating too many carrots since he arrived on Earth (they didn't have carrots on his planet). If you add that to his drinking problem, you can see why some of the ratings stated by the ball manufacturers may be a little dubious.

It's Harvey's fault.

The Truth about Dogs and Cats and 7 Foot Tall White rabbits and Bowling Balls

Are you going to trust the evaluation of a left handed, almost blind and somewhat drunk 7 foot tall white rabbit, or will you simply look at the numbers, the real numbers that cannot be stretched or fudged a little this way or that.

If a bowling ball is designed to be a “snappy” ball, then use it as a snappy ball. If it is designed to be an “arcy” ball, then use it as an arcy ball. Don’t purchase an acry ball and then ask the pro shop professional to drill it to make it snap at the end. In the same way, don’t buy a snappy ball and ask the pro shop professional to drill it to make it arc at the end.

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Oh, by the way, I don’t have any 7 foot tall white rabbits at my home. My wife and I have 1 dog and two cats.

None of the pets bowl or drink alcoholic beverages.