AUDITOR MOI SPEED MATCH

GOLF CLUB MOMENT OF INERTIA MEASURING INSTRUMENT & MOI MATCHING SYSTEM

OPERATION MANUAL
070200

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1 An Introduction To MOI

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Before proceeding, it will be useful to gain a feel for what is meant by moment of inertia, or MOI, when we refer to the fully assembled golf club. We know that when we try to move any object, it resists our efforts according to its mass. If a mass is attached to the end of a rod and swung from point A to point B, it offers a certain resistance to our efforts. If the rod is lengthened, it is more difficult to make the swing in the same time as before because the MOI of the entire mass and rod as one object has been increased. Therefore, if we consider the object in our example to be a golf club, the MOI is a measurement of the golf club's ability to resist our ability to rotate the golf club around our body.

We can then say that MOI is the parameter that resists our efforts to swing and rotate the club around our body in the swing. The MOI can be increased by increasing the length through which the mass of the club is rotating and/or by increasing the mass of the club itself. Or, the MOI can be decreased by shortening the length and reducing the mass of the club. In addition, MOI can be changed by altering a combination of the length and mass of the golf club.

A golf club that has a large MOI will require more effort to swing than a golf club that has a smaller MOI. The proper MOI of the golf club for the golfer thus has a direct bearing on the golfer's strength, swing speed and the amount of control that the golfer has on the golf club when accelerating during the downswing. This generates the energy potential needed to propel the golf ball some distance away and along a desired trajectory. The energy potential of the golf swing can therefore be optimized by adjusting the MOI of the golf club to suit a particular golfer.

One of the goals in the fitting process will be to determine what exact MOI is best for each golfer. If that can be identified, then the MOI Speed Matching System will enable clubmakers to build golf clubs to a matched MOI so that all of the clubs in a set will require the same effort to swing. If this is done, the golfer should experience an improvement in consistency in being able to strike the ball on-center a higher percentage of the time, which in turn will translate into greater distance and better accuracy overall.

1.1 Golf Club Swing Weight & MOI

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In the 1920s, the concept of swing-weight was introduced as a simple-to-understand approximation of MOI matching. Along with it, a device was created for making swing-weight measurements called a swing-weight scale to enable clubmakers to build golf clubs to a specific swing-weight measurement. If a set of clubs having the *same exact grips* and *completely identical shafts* trimmed incrementally are matched by swing-weight using only the club head for making adjustments, then the MOI of each club will be reasonably matched.

This was the original intent for the swing-weight process and worked reasonably well for the clubs of the time. However, because swing-weight is a static property of a club and moment of inertia is a dynamic property of a club, swing-weight matching is, at best, an approximation of the technically more useful MOI matching. Also, with more

modern shafts, that have purposeful variation along their length, and the tendency to mix and match a variety of shafts and club-heads within a single set, the less likely it is that a swing-weight matched set will resemble an MOI matched set.

The moment of inertia contributes to the swinging feel of the golf club and thus also influences the golfer's ability to swing the club with consistency. But because the swing-weight scale is not an MOI measurement device it does not produce a set of clubs with matching moment of inertia.

1.2 Matching Clubs Using MOI

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Golfers believe correctly that consistent performance is significantly improved by the use of a matched set of clubs. However in the context of MOI, the term "matched set" truly means that all the clubs in a set will *each* ***require the same exact effort and feel exactly the same when they are swung*** . There is only one way to realize such a set of clubs as follows:

·**All of the clubs are the same length**

·**All of the clubs use the same exact shaft and grip models with all of the shafts and grips being of equal weight and balance point.**

·**All of the club heads in the set weigh exactly the same with each head's center of gravity in the same location from head to head. If such a set of club heads can be obtained, the shot making ability of each club for spin and distance and trajectory will be controlled by loft alone. The lie angle of each club in the set would have to be the same since all clubs are made to the same playing length.**

Clubs designed in this manner will have three equal parameters: first and second moments (first moment is the swing-weight, second moment is the MOI), and equal weights. All three of these parameters must be precisely equal to achieve a truly matched set of clubs.

However, because of tradition, clubs designed in this manner which have been introduced in the golf industry failed to gain enough acceptance to be commercially successful. In so doing, golfers indicated their preference for sets made with graduated lengths and head weights for the clubs within their sets of woods and irons.

It is not physically possible to match all three parameters of first moment (swing-weight), second moment (MOI) and total weight in a set of clubs made with graduated lengths. However, it is possible to match the most important of these three parameters and realize improved performance. That parameter is the second moment, called the Moment of Inertia, or called just the MOI.

The MOI is technically defined as the sum of all of the individual masses of a system times the square of the distance of the center of gravity (CG) of each mass from the center of rotation plus the MOI of each of the components about its own CG. In other words, if we divide a object that is to be rotated into different 'chunks' of mass, the MOI of each 'chunk' is equal to its mass times the square of the distance from its CG to the center of rotation plus the MOI of the chunk about its own CG. To find the total MOI of the object, we merely add up the MOI contribution of each 'chunk'. This definition helps in a scientific understanding how the MOI is affected by changes in each of the parameters.

When the length of a golf club is increased, or if mass is added anywhere to the club, the MOI will increase. Therefore, if the MOI of each club in a set is determined, the set can be matched by adding the correct amount of weight or making a length adjustment to each club so that the MOI of every club equals the club with the preferred MOI of the set. Weight may be removed to lower the MOI of a particular club to that of the club having the smallest MOI; however, it is virtually impossible for clubmakers to remove weight from existing golf club heads, shafts or grips. As an alternative, the MOI can be reduced by decreasing the shaft length. Of course there is a chance this may result in the lengths of the clubs not being a good fitting match for the golfer, so this is only considered an acceptable way to reduce the MOI of a club if the length decrease required to match the MOI of all clubs allows the playing length of each club to still fit the golfer.

For those who are already familiar with prior attempts at MOI matching before the advent of the MOI Speed Matching System, these methods were approximate at best because they did *not* include a way to *precisely measure the true MOI of any golf club* . Thus, these prior methods are in fact no better than swing-weight matching.

1.3 Optimizing Feel Through MOI

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The MOI of a golf club is a quantifiable, real physical property that best describes the "feel" of a golf club during the swing before impact and how it relates to the individual swing of a golfer. A club that "feels right" enables the golfer to develop more consistency and thus achieve his or her maximum shot potential. A club or clubs that do not feel right will result in inconsistency and a higher percentage of poor shots.

The MOI of a golf club and how it relates to the golf swing is an example of how well the various components of the golf club can be made to inter-act with each other and ultimately with the golfer's swing characteristics. The golf club, the golf swing and their interaction can never be separated from each other or dealt with from an analytical stand point as two separate and unrelated entities. Likewise no single component of either the golf club or the golf swing can be singled out as the ultimate determining factor for performance enhancements.

The effect of MOI on the performance of the golf clubs within a set, as well as the effect of golf club MOI on golfers can be easily observed and experimented with on a daily basis. Let's consider the following facts and how they relate to MOI.

For the purpose of illustration a golfer can be described as a motor that creates energy for swinging a golf club and ultimately launching a golf ball. The energy potential that is available from this "motor" (the golfer) is a finite quantity that is used to impart motion to the golf club. Each golfer can generate their particular level of energy, regardless of the club MOI, based on their strength, and athletic ability. How efficiently this energy potential can be converted into clubhead speed is determined, in large part, by the golfer's swing mechanics. The golfer's energy can be delivered to the golf club as both translational and rotational motion of the golf club. The rotational motion (in this case rotation about a pivot at the golfer's wrist; about the butt of the club) can be scientifically related to one half of the product of the MOI and the square of the angular velocity about the pivot point. Increasing the MOI of the club decreases the angular velocity able to be generated by the golfer, which will result in less clubhead speed. Conversely, reducing the MOI of the club will result in greater angular velocity and, potentially, greater clubhead speed.

The physical relations governing the collision between two bodies tell us that, for a

constant clubhead velocity, the greater the mass of the clubhead, the greater the ball velocity. Simply increasing the clubhead mass, however, will not necessarily produce a higher ball velocity for a given golfer, as increasing the clubhead mass without changing the shaft and grip will increase the MOI of the club and, for a constant effort from the golfer, result in a lower angular velocity and a reduction in clubhead speed. This reduction in clubhead speed will offset the ball velocity gains from the greater clubhead mass. The challenge for the clubmaker is finding a combination of components, a particular MOI, which provides an optimum performance for the golfer

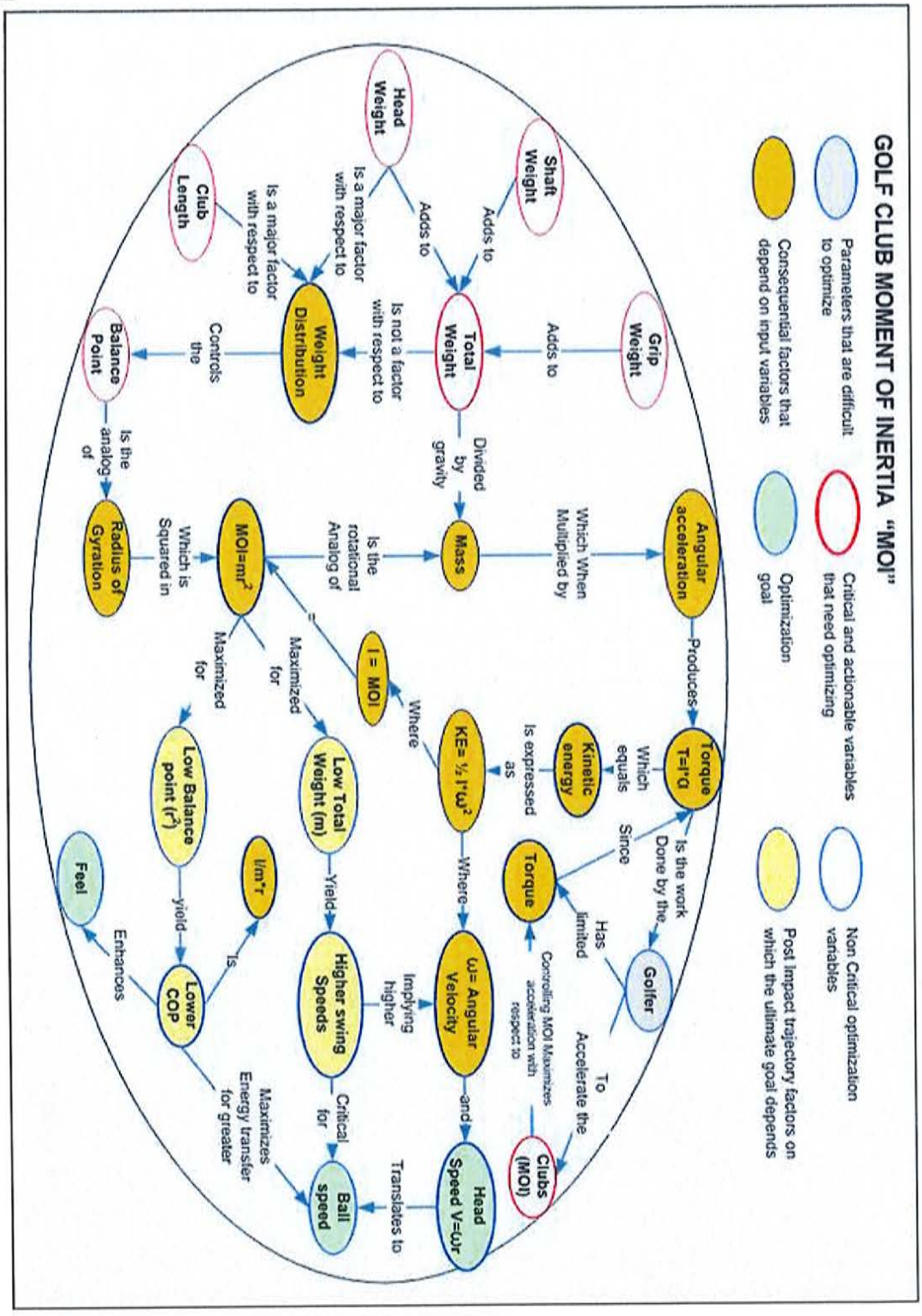
The total moment of inertia of a golf club is the sum of the MOI of the three main components, which can be varied in combinations to preserve the original MOI of the club and provide improved performance for the golfer. The primary components that we can vary to optimize club performance are the shaft and the clubhead. For instance, increasing the head weight and lowering the shaft weight appropriately so that the original shaft length can be retained will preserve the original MOI and can result in increased ball velocity.

Although the grip has a significant effect on swing-weight, its effect on MOI is minimal. This is because the CG of the grip is relatively close to the rotational axis which is used in determining the MOI.

There are an infinite variety of combinations of shaft and head weight that will produce a given club MOI. We must constantly remember that our goal is a set of clubs optimized for a particular golfer. This means that the MOI of the clubs in the set should be optimized for a particular golfer's swing characteristics and the clubhead weights and shaft lengths and weights determined to provide uniform distance increments for each club in the set. This is in addition to all the other parameters we adjust to fit a set of clubs to a particular golfer.

Keep in mind that these discussions assume a constant effort from the golfer. Improvements in the golfer's strength or improvements in swing mechanics that will improve the conversion of energy in the golfer's swing to clubhead speed are also effective ways of improving a golfer's performance.

Conclusion: Using the moment of inertia of golf clubs to enhance the fitting process is an exciting capability now available to clubmakers. It is new to most clubmakers and even newer to their customers. It has the potential for substantial improvements in a golfer's swing consistency and reliability and provides a true value added capability for the clubmaker. As we continue to improve our fitting techniques and our ability to communicate to our customers the benefits and importance of MOI matching, our, and their, understanding and appreciation will rapidly grow.


GOLF CLUB MOMENT OF INERTIA "MOI"
Parameters that are difficult to optimize
Critical and actionable variables that need optimizing
Non Critical optimization variables
Consequential factors that depend on input variables
Optimization goal
Post Impact trajectory factors on which the ultimate goal depends
Shaft Weight
Head Weight
Club Length
Grip Weight
Total Weight
Weight Distribution
Balance Point
Angular acceleration
Mass
Radius of Gyration
Torque T=I*α
Kinetic energy
Torque
Golfer
Clubs (MOI)
MOI=mr²
I = MOI
KE= ½ I*ω²
ω= Angular Velocity
Head Speed V=ωr
Low Balance point (r²)
Low Total Weight (m)
Higher swing Speeds
Ball speed
Lower COP
I/m*r
Feel
Adds to
Is a major factor with respect to
Is not a factor with respect to
Controls the
Is the analog of
Divided by gravity
Which When Multiplied by
Produces
Which equals
Is the work Done by the
Since
Has limited
To Accelerate the
Controlling MOI Maximizes acceleration with respect to
Is expressed as
Is the rotational Analog of
Where
Which is Squared in
Maximized for
Implying higher
Yield
Critical for
Translates to
and
Maximizes Energy transfer for greater
Enhances
Is

1.5 MOI Speed match Software

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The MOI Speed Matching system is build around classic concepts in physics. This software can be very accurate. There are no assumptions withing the equations or the operational logic. The degree of accuracy is dependent on accuracy of the instrumentation used to collect the data and the users patience.

At this writing, the definition of an adequate moi match is not known. An acceptable moi difference between clubs is probably related to the golfer's skill level. To overcome this lack of knowledge, this software permits the user to be as accurate as desired, within the limits of the instrumentation.

After studying this instruction manual You will be ready to use the software. After a couple of tries, you will be proficient enough to build clubs to an MOI match.

2 MOI Matching Methods

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There are *three methods* which may be used to determine club MOI and the means to achieve an MOI match:

1) MOI matching of Assembled Clubs
2) MOI matching of Un-assembled clubs by Weight
3) MOI matching of Un assembled clubs by length

The first two methods take a "hands on" approach where key measurements taken from the clubs or components to be assembled are used to calculate the MOI of each club in the set after which any weight adjustments needed for an MOI match are performed. Both methods are straight forward and afford the clubmaker a high level of accuracy. However, the clubmaker is ***limited to making headweight adjustments*** to achieve the desired club MOI.

The third method is quite similar to MOI matching of un-assembled clubs by weight and an additional step that requires the Clubmaker to tip trim the shaft by some quantities to determine the MOI change and the corresponding shift in the shaft balance point and weight when the shaft is trimmed to the calculated length for achieving the MOI match.

Please Note: *Other possibilities for weight adjustment locations are discussed here*
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IMPORTANT POINT!! *It should be noted that it is best to MOI match irons-to-irons and woods-to-woods, and at this point in equipment technology, not to attempt to make the woods and irons within a set both to the same MOI. The reasons for this are that the club length difference between woods and irons is quite substantial and conventional clubhead construction does not allow for significant weight variation up or down Thus if one was to match a set of woods and irons all to the same MOI, the iron clubs will end up requiring far too much weight or too substantial length adjustments as to render the set unplayable. One has to remember that club length*

and head weight are major factors in the MOI formula and thus the longer the club or the heavier the head, the larger the MOI

2.1 MOI Matching Assembled Clubs

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This MOI matching method addresses the need of those clubmakers to MOI match a set of existing clubs. It is done in three distinct steps:

1) Key measurements are taken for each club in the set and tabulated to facilitate error free data entry into the MOI matching software.

2) When the data entry is complete; the MOI matching software calculates the MOI for each club in the set. The golfer's favorite club is measured and its MOI input into the program so that any weight adjustments required for each club can be calculated for an MOI match.

Please Note: *possible locations for weight adjustment are discussed here .*

3) The weight adjustments calculated by the MOI matching program are then used to re-balance each club in the set using familiar weight adjustment techniques as practiced by clubmakers when building sets of clubs from components.

2.1.1 Parameters to be Measured

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- Golf club length (inches)
- Golf club MOI in Kg-cm^2
- Clubhead location where additional weight can be added to alter the club's MOI (inches)

2.1.2 Equipment Needed

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- Masking tape
- Accurate 48" clubmaking ruler
- Scale capable of accurately and repeatedly resolving to 1 gram or less *0.5 gram resolution or better is preferred*
- Golf Club MOI measuring scale
- Lead tape
- MOI worksheet for Assembled Irons or Woods

You will also need to make a note of the golfer's favorite iron, and/or wood.

2.1.3 Measurements

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During the matching process, there are some required measurements. To achieve accurate results, club makers need to be familiar with the equipment and procedures for collecting the data. Remarks below may be of value.

MOI SCALE
Before using your MOI scale for the first time, you will need to level it off on your workbench and calibrate it as instructed in the manual. Turn you scale on and slide the golf club on the beam. You may haveto lock the club in to eliminate backlash, as the club oscillates. Twang the beam and take a reading. Two sucessive readings should be less then 1% appart at most. Use the first four digits and ommit the rest.

WEIGHT SCALE
Calibrate the scale when you first receive it and check it periodically. Turn on the scale and allow it to stabilize. Place the object to be weighed on the tray and take the reading after the scale settles down. Use all the digits.

RULER
This is used to determine the balance point of the clubs. Balance the club with its shaft on an edge and measure the distance between the end of the grip and that Point. Try to take this measurement to at least the nearest 1/16 inch, or better if possible.

2.1.4 Measuring the Clubs

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For each club, including the "favorite" **, starting with the longest or shortest club:**

1) Determine the Length of the club **Show Me**

TIP: You can enter these values directly into the program, but it is generally quicker to write down all the measurements required on an MOI worksheet and then transfer them all into the program.

2) Weigh the club and record the weight in grams, to the resolution of your scale.

3) Determine each club's Moment of inertia **Show me**

4) Assuming that you will be using lead tape to adjust headweights, determine where it will be placed **Show me**

When you have measured all the clubs, your MOI worksheet should look similar the example below. In this case, the golfer's 6 iron is the favorite:

Assembled Clubs MOI Worksheet Irons				
Favorite club: 7			MOI: 2525.54	
Club No.	Club MOI kg-cm^2	Club Length (inch)	Weight Position (inch)	Grams (+/-)
1				
2				
3				
4	2557.94	37.5	0.5	
5	2553.93	37	0.5	
6	2519.13	36.5	0.5	
7	2525.54	36	0.5	
8	2495.61	35.5	0.5	
9	2548.65	35	0.5	
PW	2535.28	34.5	0.5	
SW	2517.17	34.5	0.5	
UW				

2.1.5 Calculating the MOI Match

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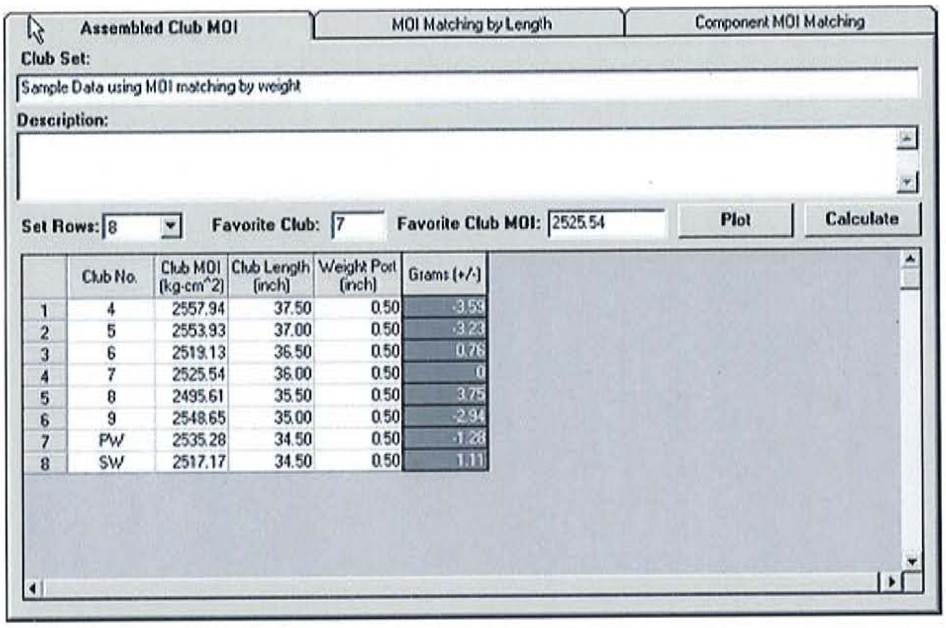
The MOI software will utilize the information obtained by measuring the clubs to be matched, as well as the information about the golfer's "favorite club", to calculate how much weight should be added to or subtracted from the golfer's other clubs to achieve an MOI match.

The MOI of the golfer's favorite club will then be used to calculate how much weight should be added to or subtracted from the golfer's other clubs to achieve an MOI match.

1) Start the MOI Speed Match program.
2) Click on the window tab **Assembled clubs** to begin recording the measured information of the clubs to be matched.
3) Enter the relevant information for the set such as the set name and the set description
4) Click on the **Set rows** tab and pick a number that matches the numbers of clubs that need analyzing.
5) Add the measured information *for each club* and record where any needed headweight will be added
6) Enter the MOI value for the "favorite club's" MOI so the other clubs can be matched against it
7) Determine the headweight adjustments needed for each club so that they can match the "favorite club".
8) Make the needed adjustments
9) Document your set specifications and save your file in the working directory and you are done!



	Club No.	Club MOI (kg-cm^2)	Club Length (inch)	Weight Port (inch)	Grams (+/-)
1	4	2557.94	37.50	0.50	-3.53
2	5	2553.93	37.00	0.50	-3.23
3	6	2519.13	36.50	0.50	0.76
4	7	2525.54	36.00	0.50	0
5	8	2495.61	35.50	0.50	3.75
6	9	2548.65	35.00	0.50	-2.94
7	PW	2535.28	34.50	0.50	-1.28
8	SW	2517.17	34.50	0.50	1.11

2.2 MOI Matching using Components

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This MOI matching method addresses the need of those clubmakers who wish to build a set of MOI matched clubs from components. This method works just like the procedure described for matching sets of assembled clubs, only it uses "dry-assembled" clubs.

It should be noted that the MOI matching using components requires additional measurements, which are used in the MOI matching calculations, to predict what the characteristics of the clubs will be before final assembly. This will allow the club maker to make the necessary adjustments that will be suit the needs and abilities of the golfer to be fit.

MOI matching using components is restricted to the weight adjustment method which is more practical and give satisfactory and predictable results for most golf club fitting applications.

Please Note: possible locations for weight adjustment are discussed here .

MOI matching of components is done in three distinct steps:

1) Key measurements are taken for each club in the set and tabulated to facilitate error free data entry into the MOI Speed Matching software.

2) When the data entry is complete; the MOI matching software calculates the MOI for each club in the set. The favorite club in the set is "hand picked" and its MOI input into the program so that the weight adjustments required for each club can be calculated for an MOI match.

3) The weight adjustments calculated by the MOI matching program are then used to re-balance each club in the set using familiar weight adjustment techniques as practiced by clubmakers when building sets of clubs from components.

2.2.1 Parameters to be Measured

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- Golf club length (inches)
- Golf club total weight (grams)
- Golf club balance point (inches)
- Golf club MOI using the MOI scale
- Clubhead location where additional weight can be added to alter the club's MOI (inches)

2.2.2 Equipment Needed

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- Knife edge on which to balance the club, e.g., blunt clubmakers' knife or length of hacksaw blade
- Masking tape
- Accurate 48" clubmaking ruler
- Scale capable of accurately and repeatedly resolving to 1 gram or less. *0.5 gram resolution or better is preferred*
- MOI measuring scale
- Lead tape, weight plugs, or shaft tip weights
- Split grip identical to the one to be installed on the new set of clubs **Show Me**
- MOI worksheet for **Components MOI matching**

- **Pocket calculator to carry out simple arithmetic**

Reminder!
You will also need to make a note of the golfer's favorite iron and/or wood

2.2.3 Set Up

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- Perform all required tip and butt trimming for the shafts and secure each head to its shaft without epoxy so the head will not fall off the shaft when measuring the club MOI.

- Dry-Assemble the clubs, apply any grip build-up tape (if required in the golfer fitting) to the shaft butts so that its weight is accounted for in the MOI measurement.

- Prepare a split grip of the same make, model and size as will be fitted to the finished clubs by cutting two longitudinal slits in it, 180° apart and to within 0.5" of the grip cap.

2.2.4 Measuring the Clubs

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For each club , including the "favorite" , starting with the longest or shortest club:

1) Push the split grip on to the shaft butt and ensure that it is fully seated. Apply a wrap of masking tape around the bottom of the grip to ensure that the grip cannot slide off the shaft.

2) Find the Balance Point of the club **Show Me**

3) Determine the Length of the club **Show Me**

TIP: *You can enter these values directly into the program, but it is generally quicker to write down all the measurements required on an MOI worksheet and then transfer them all into the program in one session.*

4) Weigh the club and record the weight in grams, to the resolution of your scale.

5) Determine each club's MOI **Show me**

6) Next, decide on ***how*** any needed weight will be added to the heads and record the appropriate measurement, ***as the measurement methods are different*** .

Please Note: *The measurements will ultimately be entered as inches. However, many club head measurements are expressed in millimeters. Divide the mm value by 25.4 to convert it to inches.*

·If you will be using ***lead tape*** to adjust headweights, record:

Middle of the lead tape to the ground line **Show Me**

·If you will be using ***weight plugs*** **at the bottom of the hosel bore** , record:

HTS (Hosel To Sole length) less the HBD (Hosel Bore Depth) plus one-half the length of standard weight plug. Based on information available from most component suppliers, the heaviest weight plug designed to fit inside a weight port is 9 grams in weight,13 mm long and 7 mm in diameter. the smallest weight plug is 2.5 grams and 13 mm long. If during an MOI match the weight addition is to be less than 2.5 grams cut the weight plug length in half. The position error for most cases using this weight plugs will be less then 3 mm at most. **Show me**

·If you will be using ***shaft tip weights*** , record:

HTS (Hosel To Sole length) less HSD (Hosel Shafting Depth) plus one-half the length of the tip weight **Show Me**

When you have measured all the clubs, your MOI worksheet should look similar to the example below. In this case, the golfer's 7 iron is the favorite.

Please note:
HTS, Bore Depth, and tip weight length are the measurements needed to derive the position on the club where additional mass can be added for an MOI match. These measurements are not entered in the software. The weight position must

be calculated manually and the result for each club in the set is then entered into the software.

Components MOI Matching Worksheet								
Customer name: Trial iron set								
Favorite club: #7			MOI	2671.55 Kg-cm^2				
Club No.	Club Length (inch)	Balance Point (inch)	Club Weight (gram)	Club MOI (kg-cm^2)	HTS inch	Bore depth inch	1/2 tip weight length	Weight Position (inch)
1								
2								
3	39.25	29.84	383	2754.59	2.5	1.25	0.5	1.75
4	38.75	29.68	387.7	2733.57	2.5	1.25	0.5	1.75
5	38.25	29.5	395.1	2730.18	2.5	1.25	0.5	1.75
6	37.75	29.18	401.1	2710.36	2.5	1.25	0.5	1.75
7	37.25	28.94	403	2671.55	2.5	1.25	0.5	1.75
8	36.75	28.94	407.6	2676.58	2.5	1.25	0.5	1.75
9	36	28.56	414.4	2649.66	2.5	1.25	0.5	1.75
PW								
SW								
US								

2.2.5 Calculating the MOI Match

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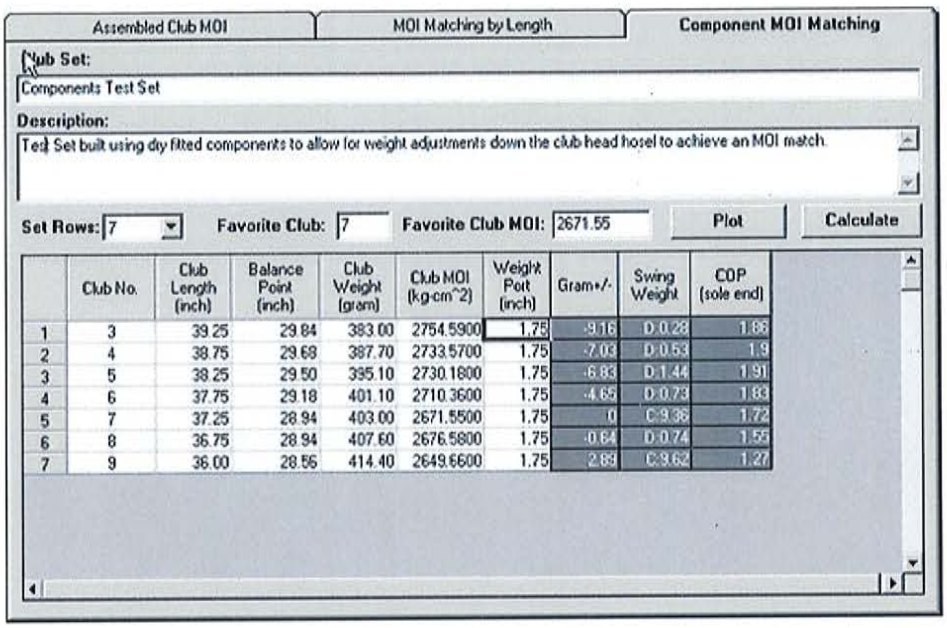
The MOI software will utilize the information obtained by measuring the clubs to be matched, as well as the information about the golfer's "favorite club", to calculate how much weight should be added to or subtracted from the golfer's other clubs to achieve an MOI match.

The MOI of the golfer's favorite club will then be used to calculate how much weight should be added to or subtracted from the golfer's other clubs to achieve an MOI match.

1) Start the MOI program and click on the Component MOI matching worksheet tab.
2) Enter the information for the set in the appropriate section and add the measured information *for each club* and record where any needed head weight will be added. Save the file to your working directory when done.
3) Click the calculate button. The weight adjustments for each club in the set is calculated, along with the actual swing weight of the clubs before MOI matching along with the COP (center of percussion).
4) Make the needed adjustments, and recheck the clubs on the MOI scale.
5) Document your set specifications save your file and you are done!

Very Important!
The swing weight and the COP for the set are calculated for the actual clubs and not the MOI matched clubs. If you wish to find out what the projected swing weight and COP is going to be you need to take a new set of measurement once the clubs are assembled and the data entered back into the program as a separate file.



	Club No.	Club Length (inch)	Balance Point (inch)	Club Weight (gram)	Club MOI (kg-cm^2)	Weight Port (inch)	Gram+/-	Swing Weight	COP (sole end)
1	3	39.25	29.84	383.00	2754.5900	1.75	-9.16	D 0.28	1.86
2	4	38.75	29.68	387.70	2733.5700	1.75	-7.03	D 0.53	1.9
3	5	38.25	29.50	395.10	2730.1800	1.75	-6.83	D 1.44	1.91
4	6	37.75	29.18	401.10	2710.3600	1.75	-4.65	D 0.73	1.83
5	7	37.25	28.94	403.00	2671.5500	1.75	0	C 9.36	1.72
6	8	36.75	28.94	407.60	2676.5800	1.75	-0.64	D 0.74	1.55
7	9	36.00	28.56	414.40	2649.6600	1.75	2.69	C 9.62	1.27

2.3 MOI matching by Length

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Club sets normally has a length increment of 1/2 inch between numbered clubs. When moi matching by means of trimming only, these increments will not be equal because of typical production variations in head weights. However, weights may be added to to the head to create an increase in moi. This process is similar to that described in previous sections. So we will focus on MOI matching using length only.

Please note that in general, the favorite moi for irons will differ from that for woods because of the significant difference in length and head weights. It is however possible possible to use the same moi but at the expense of much higher iron moi ans slower swing speeds.

2.3.1 Equipment Needed

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- Masking tape
- Accurate 48" clubmaking ruler
- Scale capable of accurately and repeatedly resolving to 1 gram or less. *0.5 gram resolution or better is preferred*
- MOI measuring scale
- Lead tape, weight plugs, or shaft tip weights
- Split grip identical to the one to be installed on the new set of clubs **Show Me**
- MOI worksheet for MOI Matching by Length

- A pocket calculator to carry out simple arithmetic

Reminder!
You will also need to make a note of the golfer's favorite iron and/or wood

2.3.2 Step 1 Component Selection

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Matching a set of golf clubs using the length method requires a careful selection of the components to be used, with the aim of minimizing weight variations on grips and shafts, and that the weight increment between club heads is consistent throughout the set, to ensure that the weight distribution of the clubs when assembled will produce an MOI matched set, where the length of the clubs are manageable for the golfer.

For the sake of simplicity, MOI matching by length should be limited to shafts of the same weight, make and model. The same applies to the grips to be used. View the tight manufacturing tolerances that are now achieved on shafts, weight sorting should not be an issue since most manufacturers now have tighter specifiations.

The components that you will need are:

- **Untrimmed shaft,**
- **Golf grip split down the middle.**
- **Grip tape**
- **Club head set (Woods or Irons)**

2.3.3 Step 2 Club Head preparation

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1) Weight all the club heads and make sure that they have an even weight increment throughout the set like 7 grams increment for irons and 10 grams for woods. If the gap between clubheads need adjusting, this is best carried out by adding the appropriate amount of weight down the hosel bore. Record the weight of each club head on the MOI matching by length worksheet. **Show me**

2) Measure the HTS dimension on all the club heads. **Show me**

3) Measure the HID (Shafting depth) on all the clubheads. **Show me**

2.3.4 Step 3 Shaft preparation

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1) Weight and sort the shafts so that they are all within (+/-) one gram of each other.

2) Measure the length of an **uncut shaft** and enter the measurement into the data gathering form.

3) Take an untrimmed shaft and cut approximately one inch from its tip. Measure the length and Weigh the cut section and enter both measurements on into the data gathering form.

4) Slip the split grip on an **untrimmed shaft** and secure it with grip tape. You may need

to apply any grip build-up tape **(if required in the golfer fitting)** to the shaft butts so that its weight is accounted for.

5) Set up the MOI Scale and take an MOI reading for the headless club. ***(Headless club referes to the assembled grip and shaft only. No heads are involved at this stage).***

2.3.5 Step 4 MOI Measurement

Previous Next

1) One by one, install the heads to the Headless club. You may use a paper shim to wedge the shaft into the hosel should the clearance between the hosel and shaft be too big for a tight dry fit

2) Set up the MOI scale and take an MOI reading for each club in the set. Enter the data on the data gathering form. Remember that the same shaft and grip will be used for each measurement, and that the MOI to be measured is the MOI of the club with the untrimmed shaft length.

When you have measured all the clubs, your MOI worksheet should look similar to the example below. In this case, the golfer's 7 iron is the favorite.

MOI Matching By Length Worksheet					
Customer name: Trial iron set					
Favorite club #7		MOI	2705.06		
Raw Shaft Length	Cut Tip Section Length	Section Weight (grams)	Headless Club MOI	Headless Club MOI	
40.25	1	3.2	437.186	437.186	
Club No.	Head Weight (grams)	Tip trim	Club MOI	HID (Inch)	HTS (Inch)
3	247.3		3229.37	1.25	2.55
4	254.7		3317.11	1.25	2.55
5	260		3372.66	1.25	2.55
6	268.4		3466.14	1.25	2.55
7	276.2		3556.59	1.25	2.55
8	283.3		3642.5	1.25	2.55
9	285.3		3638.3	1.25	2.55
PW	296.3		3800.34	1.25	2.55

2.3.6 Step 5 Calculating the MOI match

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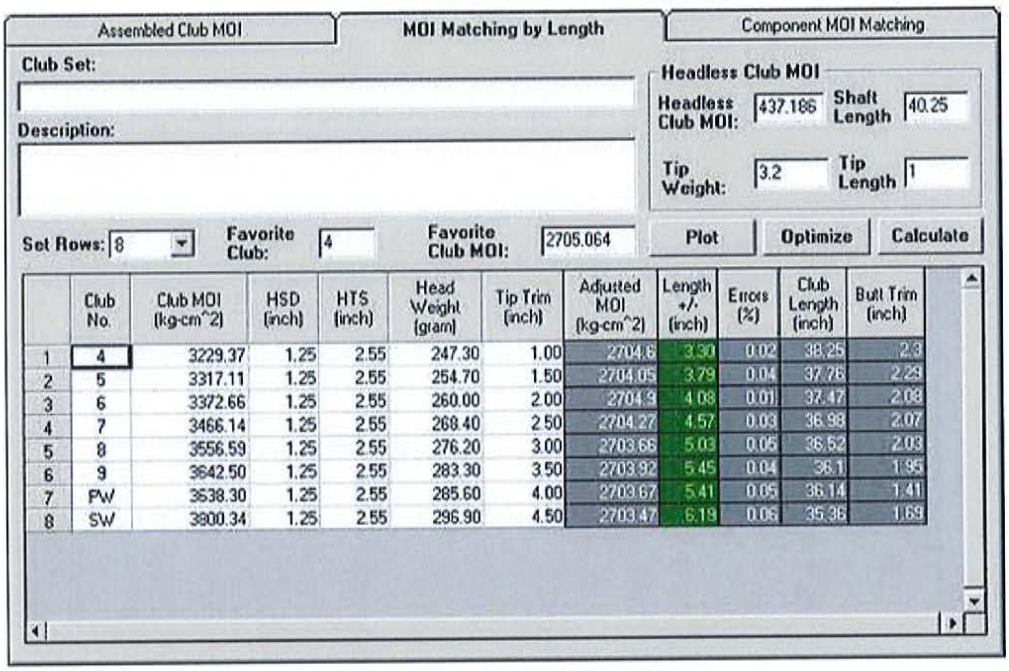
1) Launch the MOI matching by length module.
2) Enter the set name and description.
3) Enter the Headless club MOI, Raw shaft length, Tip section length and weight.

4) Enter the favorite club MOI.
5) Enter the data gathered for the untrimmed clubs, **making sure not to mistype the values to be entered.**

6) Click Calculate. The following operations are performed

*** The MOI adjustments required for each club in the set are calculated first.**
*** The trim adjustment for each club in the set to achieve and MOI match by length**
*** The Projected club length once the shafts are trimmed to spec for the MOI match.**
*** The percentage MOI error that will result in the match.**
*** The butt trim once tip trimming is performed.**



	Club No.	Club MOI (kg-cm^2)	HSD (inch)	HTS (inch)	Head Weight (gram)	Tip Trim (inch)	Adjusted MOI (kg-cm^2)	Length +/- (inch)	Errors (%)	Club Length (inch)	Butt Trim (inch)
1	4	3229.37	1.25	2.55	247.30	1.00	2704.6	3.30	0.02	38.25	2.3
2	5	3317.11	1.25	2.55	254.70	1.50	2704.05	3.79	0.04	37.76	2.29
3	6	3372.66	1.25	2.55	260.00	2.00	2704.9	4.08	0.01	37.47	2.08
4	7	3466.14	1.25	2.55	268.40	2.50	2704.27	4.57	0.03	36.98	2.07
5	8	3556.59	1.25	2.55	276.20	3.00	2703.68	5.03	0.05	36.52	2.03
6	9	3642.50	1.25	2.55	283.30	3.50	2703.92	5.45	0.04	36.1	1.95
7	PW	3638.30	1.25	2.55	285.60	4.00	2703.67	5.41	0.05	36.14	1.41
8	SW	3800.34	1.25	2.55	296.90	4.50	2703.47	6.19	0.06	35.36	1.69

Percentage error Explanations:
The software iterated the shaft length and calculated the moi for shaft length and compared it with the desired MOI value. When the MOI of the favorite club and the clubs to be build match to an acceptable accuracy, the amount of trim is then shown with the moi and percent accuracy between the calculated moi and the desired moi for each club. If the clubs are trimmed to the value shown, the resulting moi will be very close to that shown. You may trim at either end of the shaft but the ***total trim must equal the calculated value.***

Please note:
As far as MOI matching by length is concerned, butt and tip trim are interchangeable with no particular side effect. One has to remember that the MOI calculations in this instance rely on two key variables which are:

A) The club head weight
B) The club length which is the radius of gyration from the butt end of the shaft to the club head CG.

When we cut the small tip section of the shaft, measured its length and weight, the

information is used to determine the MOI change due to the loss of material from that end. Weight losses due to butt trimming's only effect on the club MOI is to reduce the radius of gyration, noting that the fulcrum / pivot point is at the butt end of the shaft. The length variation throughout the set is what sets the MOI match, keeping in mind that we started the matching process using identical shafts and grips.

For the sake of consistency, the shaft should always be trimmed at the tip as directed by the manufacturer to achieve the desired flex characteristics and then trimmed to length at the butt to achieve the MOI match.

2.3.7 Step 6 Length Optimization

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The club length displayed, assumes that the the shafts will be trimmed as indicated by the software. The club length is derived by subtracting the amount of shaft to be trimmed, the shafting depth (HID) , the Hosel to Sole measurement (HTS) and the headless club length.

More often then not, the amount to be trimmed off the shaft for an MOI match by length, will not provide the incremental progressions golfers are used to.Thus a clubmaker may wish to adjust the length to provide a relatively smooth transition from club to club, but also to simplify the trimming process. Thus for practical purposes a clubmaker may elect to round up or down the values to the nearest fraction they can reliably achieve. Once the trim is adjusted, the software re-calculates the club length and the MOI and the percentage error that will result for that trim.

Adjusting shaft trim

1) Click the calculate button to refresh the data grid.
2) Round the trim value for each club as desired. This is done by editing the values in the data grid directly.
3) When done click "Optimize". The MOI of each club, club length and percentage errors are automatically re-computed.
4) You may wish at this stage to re-adjust again the amount to be trimmed off the shaft to reduce the percentage error to an acceptable level.

	Club No.	Club MOI (kg-cm^2)	HSD (inch)	HTS (inch)	Head Weight (gram)	Tip Trim (inch)	Adjusted MOI (kg-cm^2)	Length +/- (inch)	Errors (%)	Club Length (inch)	Butt Trim (inch)
1	4	3229.37	1.25	2.55	247.30	0.00	2704.6	3.30	0.02	38.25	3.3
2	5	3317.11	1.25	2.55	254.70	0.00	2704.05	3.79	0.04	37.76	3.79
3	6	3372.66	1.25	2.55	260.00	0.00	2704.9	4.08	0.01	37.47	4.08
4	7	3466.14	1.25	2.55	268.40	0.00	2704.27	4.57	0.03	36.98	4.57
5	8	3556.59	1.25	2.55	276.20	0.00	2703.66	5.03	0.05	36.52	5.03
6	9	3642.50	1.25	2.55	283.30	0.00	2703.92	5.45	0.04	36.1	5.45
7	PW	3638.30	1.25	2.55	285.60	0.00	2703.67	5.41	0.05	36.14	5.41
8	SW	3800.34	1.25	2.55	296.90	0.00	2703.47	6.19	0.06	35.36	6.19

2.3.8 Step 7 Validating the MOI match

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To aid in the evaluation of the accuracy of measurements, a menu item called Plot Check has been added and which purpose is to show the measured data graphically. The club MOI, Club total weight and balance point increment between clubs should approximate a straight line. Club makers should be suspicious of points clearly outside the lines, and the measurments for the invalid points should be repeated.

If you wish to spend the extra time at it, cut the shafts to the desired trim and permanently install the grips. Temporarily install the heads on the correct trimmed shaft. Measure the period, club weight and balance point for each and enter the data in a new file, to check the results. You can easily correct some errors through the addition of headweight to the club.

You are now ready to use the software. After a couple of tries, you will be proficient enough to build clubs to an MOI match.

2.3.9 Important notes

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Note 1
When working in the MOI matching by length module, the club head weights are used for calculating the MOI adjustments needed for an MOI match in with respect to the measured MOI of the headless club and the MOI of the clubs in the un-trimmed state.

Thus If the club head weights are changed, the MOI of the untrimmed clubs has to be re-measured to take account of the weight added and the new MOi values entered in the software so that the length adjustments can be re-computed.

Note 2
For the sake of consistency, the shaft should always be tip trimmed as directed by the manufacturer to achieve the desired flex characteristics and then butt trimmed to length to achieve the MOI match. If the MOI matching by length prove to be unworkable after the clubs have been dry fitted, the clubs can always be butt trimmed again to produce clubs with an incremental trim and the MOI match achieved through weight adjustment instead.

Note 3
As far as MOI matching by length is concerned, butt and tip trim are interchangeable with no particular side effect. One has to remember that the MOI calculations in this instance rely on two key variables which are:

A) The club head weight
B) The club length which is the radius of gyration from the butt end of the shaft to the club head CG.

When we cut the small tip section of the shaft, measured its length and weight, the information is used to determine the MOI change due to the loss of material from that end. Weight losses due to butt trimming's only effect on the club MOI is to reduce the radius of gyration, noting that the fulcrum / pivot point is at the butt end of the shaft. The length variation throughout the set is what sets the MOI match, keeping in mind that we started the matching process using identical shafts and

grips.

3 Reference

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There are a number of reference materials provided to simplify your MOI matching, some of which are listed in this section.

Frequently Asked Questions
Assembled Clubs and Component MOI Matching Example
Listed Component MOI Matching Example
Period Counter Setup and Use
Golf Club Length definition
Golf Club Balance Point definition
HTS, HSD, and HBD head measurement definitions
Measurements needed for adding head weight

MOI Worksheets
Fraction to Decimal conversions
Millimeters to/from Inches conversions
Club Locations where mass can be added

3.1 Frequently Asked Questions

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The following are some of the more frequently asked questions that arise when MOI matching clubs. MOI matching is an emerging clubmaker's tool that has the potential to solve a lot of problems encoutered when fitting golfers of all abilities. The Dynamics of MOI chart provided in this manual, should be a good stating point to learn more about the mechanics involved.

Does MOI matching change the fitting process for the golfer?

Are there any golfer observations that would valuable in MOI fitting?

What will a golfer notice when switching from swingweighted to MOI matched clubs?

Is there any aspect of the performance of the shafts that is changed by MOI matching?

How is the right MOI determined for each golfer?

Which club should be used for the "favorite club"?

I'm building a set from listed components, what should I do if the golfer has no "favorite club"?

Will woods and irons all be built to have the same single MOI?

If I take a set of MOI matched clubs and then measure each club on a swingweight scale, what will I see?

What about the wedges – should they be built to have the same MOI as all of the re st of the irons?

How about the putter – should it be MOI matched?

How closely matched does an MOI-matched set of clubs need to be?

Can I still use my swingweight scale?

When building from components how do you handle headweight differences?

When using the Period Counter, how precise do the measurements need to be?

If I change a club's length to achieve a desired MOI will it have an effect on the club's di stance?

Can I MOI match a club with an Iron head and Wood shaft?

If I change a club's lie angle will it have an effect on its MOI?

How does MOI affect building to a butt frequency progression of the shafts?

Q: Does MOI matching change the fitting process for the golfer?
A: Not to any significant degree. MOI matching is a replacement for swingweight matching in the fitting process. Clubmakers will fit golfers for the best clubhead, shaft, grip, and length based upon their normal fitting procedures. Once these are determined then MOI matching is used to guide the clubmaker on how the clubs will be assembled with regard to final headweight, and in some cases, final length adjustments.

Q: Are there any golfer observations that would valuable in MOI fitting?
A: The following are typical tendencies that may be of help in fine tuning a golfer's MOI match:
·Slower and smoother swingers like an MOI on the lower side of the spectrum.
·Faster and more aggressive hitters like an MOI on the higher side of the spectrum.
·If the MOI is too high for a golfer, it usually will cause an early release of the wrist-cock on the downswing.
·If the MOI is too low, and the golfer doesn't feel the proper "resistance", it can result in a faster tempo and more off-center hits.

Q: What will a golfer notice when switching from swingweighted to MOI matched clubs?
A: No BS, we have yet to hear from a clubmaker using the MOI system who reported that a golfer for whom MOI matching was performed did not notice a difference in the swing feel of all of the clubs in the set, and an increase in the percentage of solid, on-center hits with the clubs. If the golfer "waggles" each MOI matched club, they may think that they detect a little different head feel. But as soon as the clubs are swung full, the golfers all report that they can close their eyes, switch clubs in the set, and not really detect any difference in the total swing feel of the clubs from each other.

Q: Is there any aspect of the performance of the shafts that is changed by MOI matching?
A: Very Rarely, if ever. The selection of the shaft is made on the basis of the same fitting procedures the clubmaker is comfortable with using. However, it is very likely that because of the final head weighting requirements of the MOI Match, the frequency progression of the shafts will be different than it would be if the clubs were only

swingweight matched. Normally, if the progression in butt frequency was 4cpm between clubs in a swingweight matched set, the progression will change in some cases, but only because of the headweight changes in the MOI set, and NOT because of any change in trimming of the shafts. In all of our testing, and in the reports of actual MOI fittings that clubmakers are performing, we have yet to hear of one case in which the golfer required an adjustment in the tip trimming to offset the progression of frequency from shaft to shaft within the set. In short, MOI matching will not affect the golfer's perception of the shaft fitting.

Q: How is the right MOI determined for each golfer?
A: Virtually all golfers who play regularly have noticed they have a "favorite club" or clubs within their current or previous set of clubs. They have confidence in hitting these clubs more consistently on-center and solid than other clubs in their set. We believes that the reason for this is that these clubs' MOI happens to match the strength, tempo, and swing mechanics of the golfer noticeably better than their other clubs. Therefore, the concept of MOI Matching is based initially on asking the golfer to bring forth their "favorite clubs" to be MOI measured and thus form the guide to which the MOI of all other clubs will be built. However, if a golfer does not have a favorite club they can still be correctly fitted, see below.

Q: Which club should be used for the "favorite club"?
A: As shorter clubs are by nature easier to hit, the longest club the golfer can reliably hit should be used. This will help avoid possible assembly problems, while at the same time providing the golfer with a well-fitted set of clubs. In general, as MOI-matched clubs get shorter their swingweights increase. Conversely, as the clubs get longer their swingweights decrease. If a golfer comes in with his PW as a "favorite club" constructing the longer clubs in the set can become a challenge, as very light headweights may be required to achieve the proper MOI. Experienced MOI-matching clubmakers are learning to push the golfer past the use of short clubs as their "favorite club" and ask them to bring in the longest club that they hit the most solid, or the longest club that they like the most, as a way to avoid this problem.

Q: I'm building a set from listed components, what should I do if the golfer has no "favorite club"?
A: In this case, you don't have a clue as to what MOI is good for the golfer, because you don't have the favorite club MOI.

There are a few ways to solve this problem. The first using a test club, the second by looking at the data from the listed component computations.

Using the first method, many clubmakers have had MOI matching success with building a test 5 or 6 iron or a test 3 or 5 wood for the golfer. The golfer hits the test club and, using lead tape, they find the headweight that results in the golfer experiencing the best on center hit percentage. Once that is found, then this test club becomes the "favorite club" and it becomes the MOI basis for the set being built.

Using the second method, enter the basic information for the set, using standard tip trims, then calculate the "largest club" MOI and look at the data. You will see that the MOI for each club is calculated, along with the swingweight, and the club total weight. Now you can see what the difference is between clubs, selecting any of the criterions. If you like the swingweight and total weight of say the 5 iron you can elect to use that club as the reference club, since it looks like it is suitable for this particular golfer. Now you have a favorite club and you know its MOI. So take the MOI of the 5 iron just selected and key it into the favorite club MOI. Run the program using the MOI Speed match system and voila you matched the other clubs in the set to the 5 iron just picked.

Q: Will woods and irons all be built to have the same single MOI?

A: No. Testing along those lines showed that because woods and irons are so different in their length and headweight ranges, better results were obtained by matching all woods to a "favorite wood" MOI, and then matching all irons to a "favorite iron" MOI.

Q: If I take a set of MOI matched clubs and then measure each club on a swingweight scale, what will I see?
A: Depending on the MOI of the "favorite club", the swingweight of the clubs in a set will normally increase from the longest club in the set to the shortest. However, what the longest club's swingweight is compared to the shortest, and what the progression in between can be quite different, again, depending on the MOI to which the clubs in the set are built, the lengths each club is fit to the golfer, and the weight and balance point of the shafts in the set as well.

Q: What about the wedges – should they be built to have the same MOI as all of the rest of the irons?
A: No. Any of the wedges that are used by the golfer for less than a full swing most of the time the wedge is used, it should not be matched to the same MOI as the rest of the irons which are almost always used for a full swing. In general, because many golfers do use the PW and AW (gap wedge) more for full swings than they do the SW and LW, it is ok to make the MOI of the PW and AW the same as the rest of the numbered irons. But for the SW and LW, they are better off being built to a lower MOI than the rest of the irons.

Q: How about the putter – should it be MOI matched?
A: Most definitely finding the right MOI of the putter for each golfer would improve performance on the greens. However, that is far easier said that done at this point in our MOI research. In the woods and irons, because there are multiples of each type of club, it is not difficult to ask a golfer to provide a present or past wood and iron that has been a "favorite club", to which all of the other woods, and then all of the other irons would be MOI matched. But with the putter, it is not that practical to ask a golfer who is not putting all that well to bring in a "favorite putter" to act as the MOI guide – logic says if the golfer had/has a favorite putter, he would be using it at present and thus not need to change the MOI. However, if the golfer DOES presently like the feel of their putter but was interested in trying a different head model in a new putter, then the favorite putter should be MOI tested to provide the MOI benchmark for building or altering the new putter so that it had the same stroke feel the golfer likes.

Q: How closely matched does an MOI-matched set of clubs need to be?
A: Testing has shown that if all clubs are within a one percent MOI range, high to low,that golfers will not note the difference whatsoever.

Q: Can I still use my swingweight scale?
A: Yes, because you can use it in a "more familiar" way to guide your MOI assembly. Here's why and how - when The MOI Speed match makes its calculations it tells you how many grams of weight to add or remove from the head of each club/clubhead to achieve the MOI match. In the section of the MOI speed match where you can match assembled clubs, MOI Speed Match tells you the existing swingweight of each club and it tells you how many grams of weight to add or remove from each club to reach the target MOI. So, in the case of a weight addition to get the MOI match, you could either just measure the weight on your gram scale and add it, or you can look at the club's swingweight and equate the weight to add to a new swingweight for each club, using the 2g = 1 swingweight point basis.

In the section of the MOI Speed match where you are building clubs from components, the MOI Speed Match tells you both the gram weight to add/remove from each head in the set, as well as tells you what the final swingweight of each club will be to achieve the MOI match. So you could again just measure the headweight change in grams, or you

can build the clubs to the swingweight needed to achieve the MOI match.

One additional use to verify the correctness of measurement data you've entered for an assembled club. If you have measured everything correctly, the swingweight predicted by MOI Speed match should be within 0.2 swingweight points of what your swingweight scale shows.

Q: When building from components how do you handle headweight differences?
A: MOI PRO assumes that all heads exactly match their designed headweight. If you have heads that are +/- the specification, simply subtract or add the difference to the gram weight adjustment that is suggested for MOI matching.

Q: When using the MOI Scale, how precise do the measurements need to be?
A: MOI sensitivity is length dependent .When measuring MOI A difference of no more than 0.01% should be obtained within two consecutive readings. If a club measures 2,700 Kg-Cm^2 a 0.01% deviation will equate to an MOI difference of 2.7 kg/cm2 - well within the acceptable MOI range bearing in mind that a one gram weight addition at 45 inches from the fulcrum equatee 1.44 Kg-Cm^2 and 0.44 Kg-Cm^2 at 35 inches.

Q: If I change a club's length to achieve a desired MOI will it have an effect on the club's distance?
A: Club length changes of less than one-half inch will have virtually no effect on the club's distance.

Q: Can I MOI match a club with an Iron head and Wood shaft?
A: Yes. You can. You only need to dry fit the shaft and head of yoru choosing, measure the relevant parameters and perform a match.

Q: If I change a club's lie angle will it have an effect on its MOI?
A: Yes, just like a substantial bend will alter the swingweight, so too it will alter the MOI of the club, but it will be such a small amount that it can be ignored.

Q: How does MOI affect building to a butt frequency progression of the shafts?
A: The conventional swingweight method of assembling clubs, with each club increasing in the butt frequency reading by the same increment, is based upon a club-to-club change of 1/2 inch in length (irons) and a 7 gram change in headweight. This results in an even progression of butt frequency through the set. An MOI matched set will have a different butt frequency progression - how much different depends upon the profile of the shaft and the MOI of the clubs. In an MOI matched set the swingweight progresses higher for each club through the set. Thus the butt frequency progression will change as well. However, TWGT believes that butt frequency is not as important for shaft fitting and matching as previously thought. The shaft's "bend profile" is what is key. If you wish to retain a consistent butt frequency progression in an MOI matched set, then gradually increase the tip trim through the set over what is normal. However, you can still account for a heavier or lighter headweight the same way you always have when accommodating a higher swingweight.

3.2 Measuring club MOI

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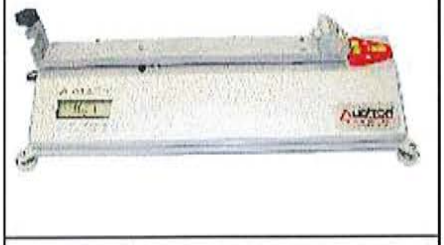
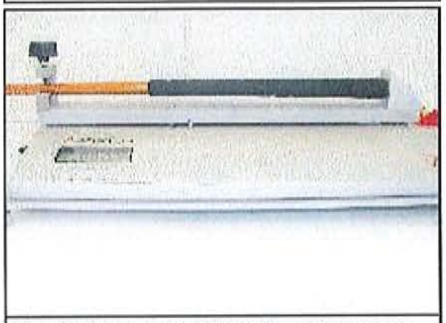
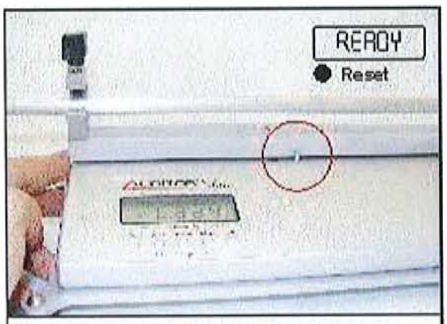


MOI
● ON

Plug in the power supply and turn the instrument to ON. The Caption MOI will show on the Display.

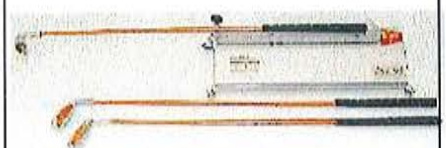


When placing a club on the beam it is not necessary to tseoure the club with the thumb screw, as long as the club points toe towards the ground and does not wobble during an oscillation cycle.



Mount the club to be measured on the Auditor MSM, and gently pull the beam until it contacts the side stop. Release the beam and press the reset button

Transfer the measurement to the worksheet, and proceed with the next club in the set when done.

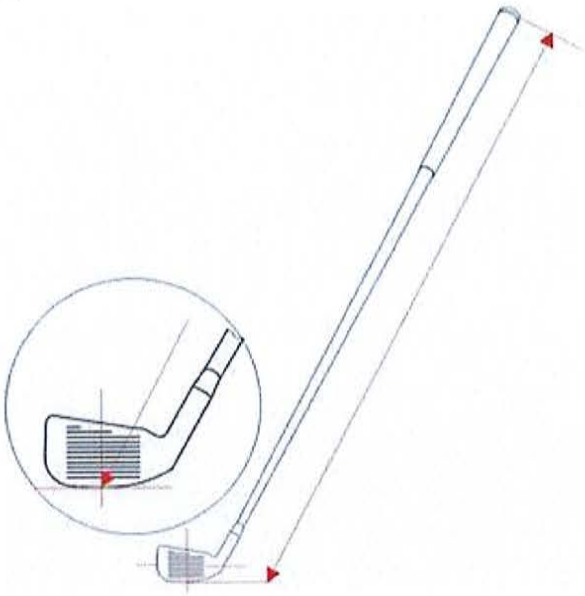


Please note:
The Auditor MSM can perform an MOI match on a full set of clubs, one club at a time, without the need for additional hardware or software. Check your user manual for details.

3.3 Golf Club Length

Previous Next

For the purpose of MOI matching the length of the golf club is measured from the center of the golf club sole right up to the very end of the grip end cap, with the golf club resting in the correct lie angle position. Length is measured in inches to the nearest 1/16 inch (0.0625").



3.4 Measuring Golf Club Balance Point

Previous Next

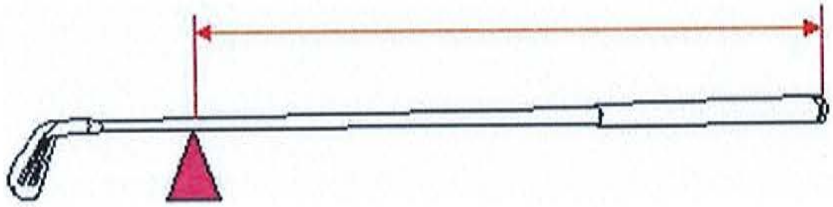
You will need a knife edge on which to balance the club, e.g., blunt clubmakers' knife or length of hacksaw blade, a vise, and masking tape to perform this measurement.

Place the knife edge in the vise, so that its top edge is approximately level and several inches above the bench top. If using a hacksaw blade, put the plain (non serrated) edge uppermost.

Find the approximate balance point of the club in by first balancing it on the tip of your finger. Apply a short length of masking tape (approx 1½" - 2") at that point. This will both protect the shaft finish (particularly in the case of graphite shafts) and/or prevent the shaft slipping.

Carefully balance the club on the knife edge and adjust until the shaft is horizontal. Mark the balance point of the club with a marker pen.

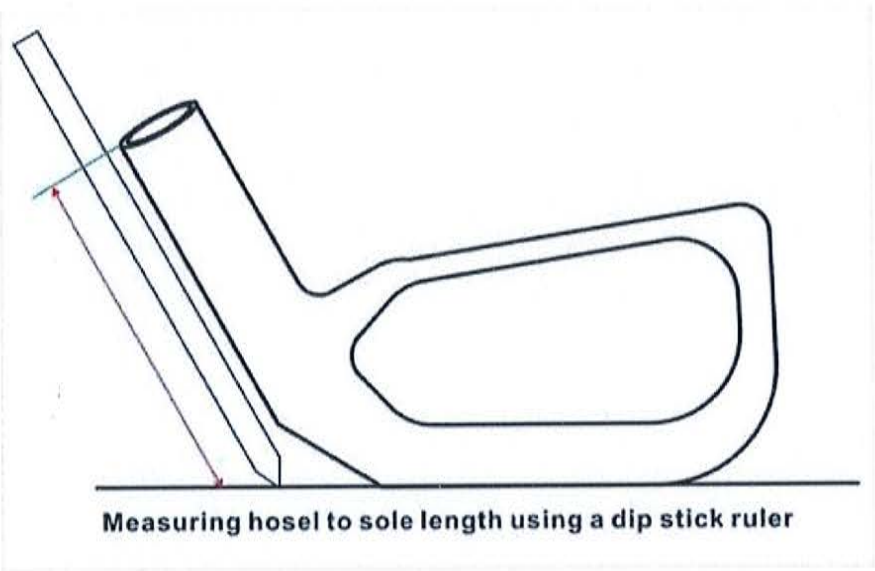
The balance point is measured from the end of the grip in inches. An accuracy of 1/16 inch (0.0625") is recommended.



3.5 Measuring HTS, HSD, and HBD

Previous Next

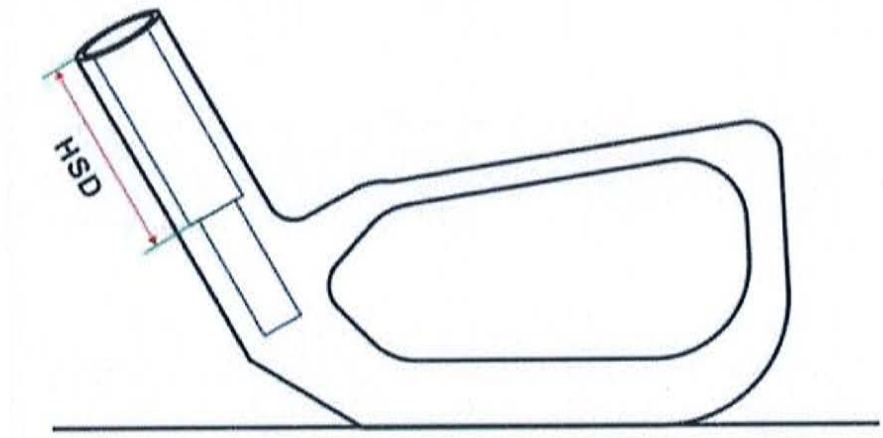
HTS "Hosel to Sole Length " is used to determine the golf club playing length. It is the height, in millimeters, between the club head sole and the top of the hosel bore, measured between perpendiculars.



Measuring hosel to sole length using a dip stick ruler

HSD "Shafting Depth " This is the amount of shaft tip, in millimeters, that's inserted inside the hosel. The insertion depth is measured with a pair of calipers or a bore depth gauge

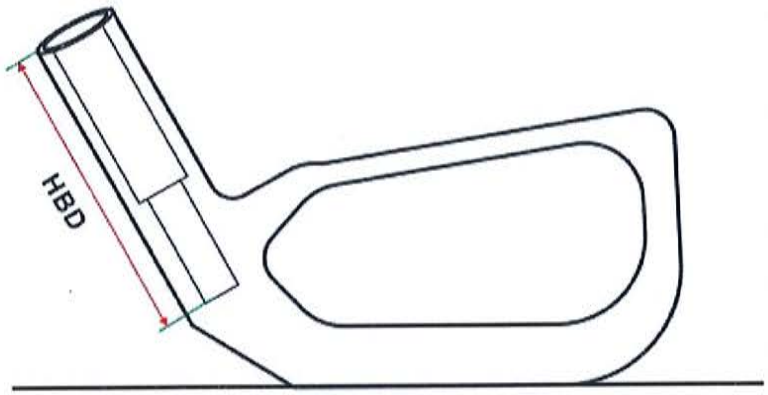
Measuring Shafting Depth (HSD)



HBD "Hosel Bore Depth " This is the measurement, in millimeters, from the top of the hosel to the bottom of the weight bore. This is measured with a pair of calipers or a bore depth gauge

Hosel Bore Depth can also be calculated as HSD (Shafting depth) plus the weight bore depth.

Measuring Hosel Bore Depth (HBD)



3.6 Adding Head Weight

Previous Top Next

Headweight can be added in a number of ways, each has different measurements that will affect the MOI computations. Each method is described as follows:

Lead tape

Weight plug

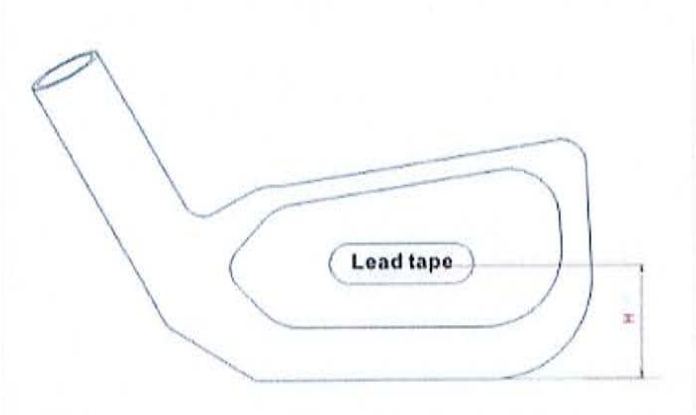
Shaft tip weight

Please Note: There are other methods of locating the weight. They are discussed here .

3.6.1 Lead Tape

Previous Next

Decide where the middle of the tape will be positioned on each clubhead. Then measure the vertical height from there to the ground line and record that dimension in inches, to the nearest 1/16 inch (0.0625") or better.



Weight position on clubhead measured from the ground line to the center of the led tape

3.6.2 Weight Plug

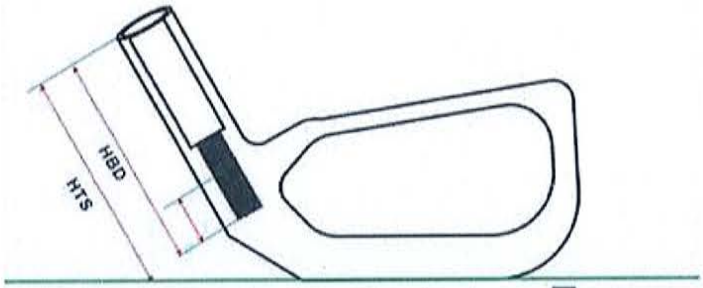
Previous Next

If you are using the clubhead weight bore to adjust the MOI headweight, calculate the clubhead weight position as follows:

HTS (Hosel To Sole length) less the HBD (Hosel Bore Depth) plus one-half the length of the Weight Plug

Hosel Bore Depth can also be calculated as HSD (Shafting depth) plus the weight bore depth.

Head weight adjustment Using Weight Plugs



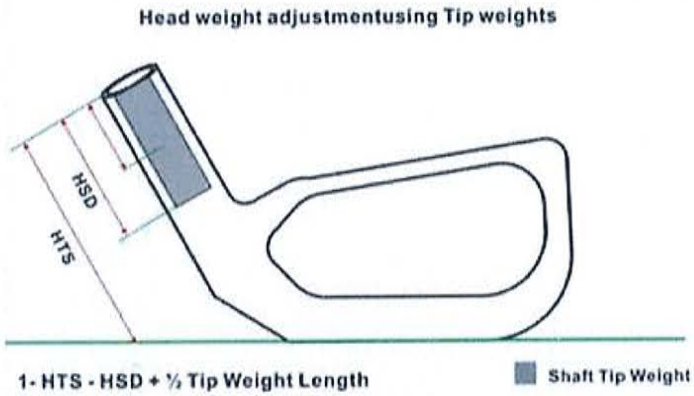
1- HTS - HBD + ½ Weight Plug Length

3.6.3 Tip Weight

Previous Next

If you are using shaft tip weights to adjust the MOI headweight, calculate the clubhead weight position as follows:

HTS (Hosel to Sole length) less HSD (Shafting depth) plus one-half the length of the tip weight



3.7 MOI Worksheets

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The following worksheets are provided for recording the information needed for various kinds of MOI matching:

Assembled Irons Worksheet

Assembled Woods Worksheet

Unlisted Component Worksheet

3.7.1 Assembled Irons

Previous Next

Assembled Clubs MOI Worksheet Irons				
Favorite club:			MOI:	
Club No.	Club MOI kg-cm^2	Club Length (inch)	Weight Position (inch)	Grams (+/-)
1				
2				
3				
4				
5				
6				
7				
8				
9				
PW				
SW				
UW				

3.7.2 Assembled Woods

Previous Next

Assembled Clubs MOI Worksheet Woods				
Favorite club:			MOI:	
Club No.	Club MOI kg-cm^2	Club Length (inch)	Weight Position (inch)	Grams (+/-)
Driver				
2				
3				
4				
5				
6				
7				
9				
11				

3.7.3 Components

Previous Next

Components MOI Matching Worksheet								
Customer name / Set name:								
Favorite club:			MOI	Kg.cm^2				
Club No.	Club Length (inch)	Balance Point (inch)	Club Weight (gram)	Club MOI (kg-cm^2)	HTS Inch	Bore depth inch	1/2 tip weight length	Weight Position (inch)

3.7.4 By Length

Previous

MOI Matching By Length Worksheet						
Customer name /Set Description						
Favorite club			MOI Kg.Cm^2			
Shaft and Grip Description			Raw Shaft Length	Cut Tip Section Length	Section Weight (grams)	Headless Club MOI
Club No.	Head Weight (grams)	Tip Trim	Club MOI with Untrimmed shaft		HID (inch)	HTS (inch)

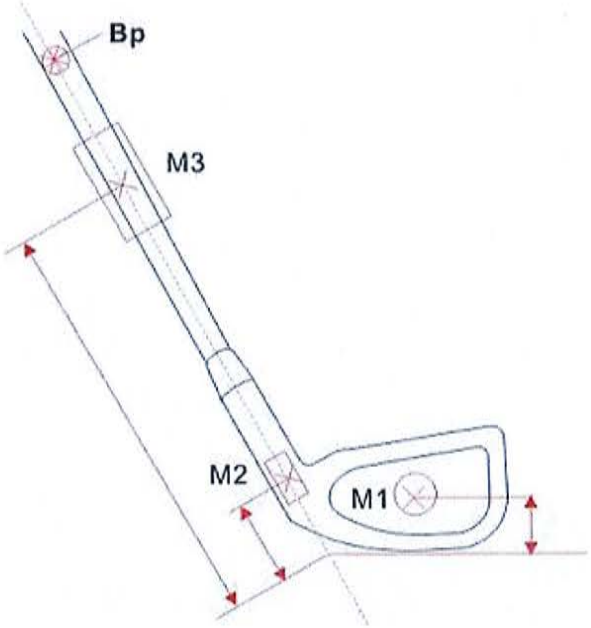
3.8 Mass Location

Top Next

When adjusting of a set of clubs for an MOI match it may be more convenient to add weight instead of adjusting the playing length of the club. When additional mass has to be added, it is important that location of the additional mass be taken into account within the MOI calculations.

The additional weight is usually best added just behind the CG of the golf club (M1) or in the hosel weight bore (M2). If this is not possible the additional weight can be added externally to the shaft (M3). In all instances the mass location is measured from the clubhead sole (origin) and cannot extend more than 20" inches above the club head and preferably below the balance point (Bp) of the golf club, otherwise the additional weight becomes ineffective.

Please Note: The default weight location is always assumed to be the bottom of the club head sole (0) unless otherwise specified.



4 Measurement Convertion

4.1 Millimeter-Inch Conversion

Top Next

Club and clubhead measurements are often expressed in a combination of millimeters and inches. At times, it is necessary to convert from one measurement from another when using MOI PRO. The following formulas will assist you.

Millimeters to Inches
Take the number of millimeters and divide by 25.4.

Example: 40 millimeters is approximately 1.6 inches, calculated as 40 / 25.4 = 1.575 inches

Inches to Millimeters
Take the number of inches and multiply by 25.4.

Example: 2 inches is approximately 51 millimeters, calculated as 2 * 25.4 = 50.8 millimeters

4.2 Inch Fractions To Decimals

Previous Next

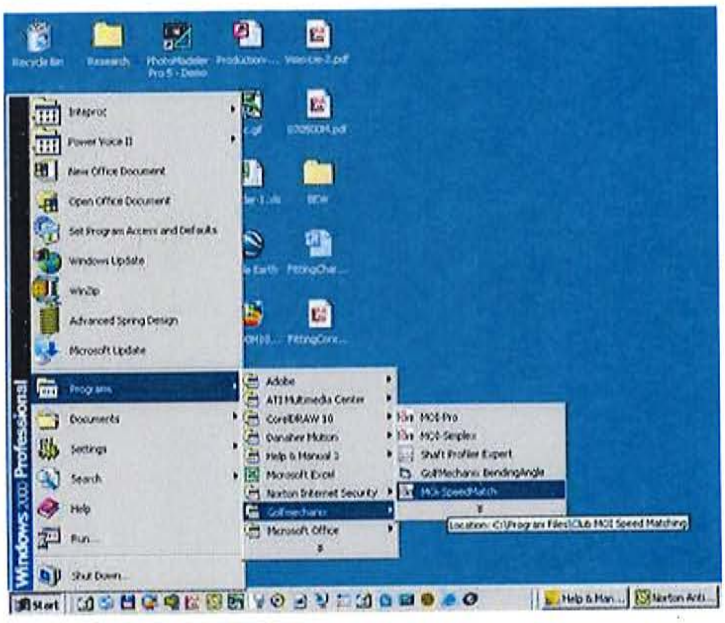
Millimeters	Fractions	Inches
0.397	1/64	0.01563
0.794	1/32	0.03125
1.191	3/64	0.04688
1.588	1/16	0.0625
1.984	5/64	0.07813
2.381	3/32	0.09375
2.778	7/64	0.10938
3.175	1/8	0.125
3.572	9/64	0.14063
3.969	5/32	0.15625
4.366	11/64	0.17188
4.762	3/16	0.1875
5.159	13/64	0.20313
5.556	7/32	0.21875
5.953	15/64	0.23438
6.35	1/4	0.25
6.747	17/64	0.26563
7.144	9/32	0.28125
7.541	19/64	0.29688
7.938	5/16	0.3125
8.334	21/64	0.32813
8.731	11/32	0.34375
9.128	23/64	0.35938
9.525	3/8	0.375
9.922	25/64	0.39063
10.319	13/32	0.40625
10.716	27/64	0.42188
11.112	7/16	0.4375
11.509	29/64	0.45313
11.906	15/32	0.46875
12.303	31/64	0.48438
12.7	1/2	0.5

Millimeters	Fractions	Inches
13.097	33/64	0.51563
13.494	17/32	0.53125
13.891	35/64	0.54688
14.288	9/16	0.5625
14.684	37/64	0.57813
15.081	19/32	0.59375
15.478	39/64	0.60938
15.875	5/8	0.625
16.272	41/64	0.64063
16.669	21/32	0.65625
17.066	43/64	0.67188
17.462	11/16	0.6875
17.859	45/64	0.70313
18.256	23/32	0.71875
18.653	47/64	0.73438
19.05	3/4	0.75
19.447	49/64	0.76563
19.844	25/32	0.78125
20.241	51/64	0.79688
20.638	13/16	0.8125
21.034	53/64	0.82813
21.431	27/32	0.84375
21.828	55/64	0.85938
22.225	7/8	0.875
22.622	57/64	0.89063
23.019	29/32	0.90625
23.416	59/64	0.92188
23.812	15/16	0.9375
24.209	61/64	0.95313
24.606	31/32	0.96875
25.003	63/64	0.98438
25.4	1	1

5 MOI Speed Match Software

Top Next

1) To access the MOI Speed Match modules, launch the program from your window task bar,



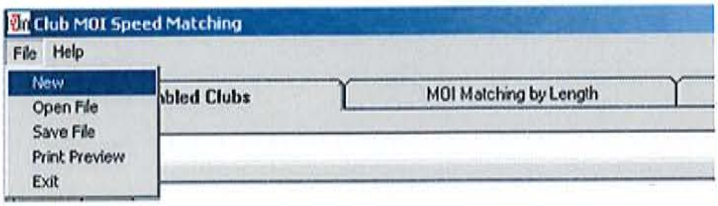
2) Click on the Splash Screen to begin.

5.1 File Menue

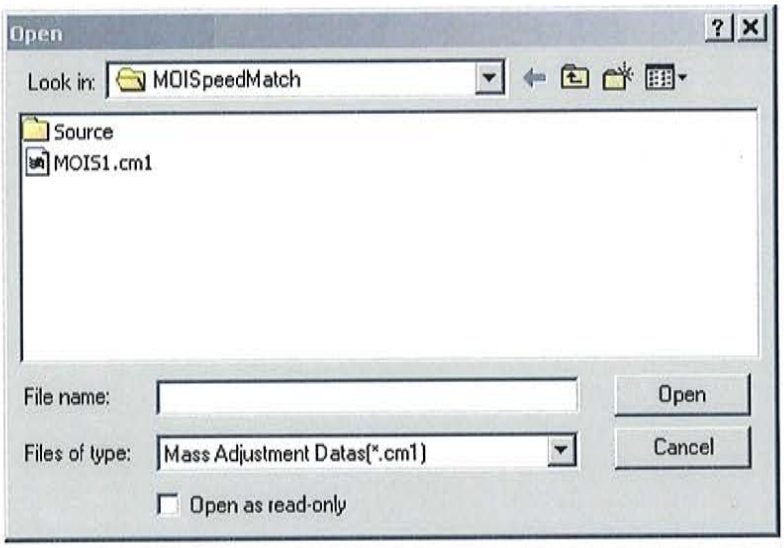
Previous Next

The File menue for the MOI Speed match is common to all three modules, each having its own file structure. Thus it is not possible to open a file unless the file extension matches that of the module from which it orginated. Howver, for ease of convenience all three modules can be opened at once but only the active module can be viewed. This makes it easy to toggle back and forth between modules should the need arise.

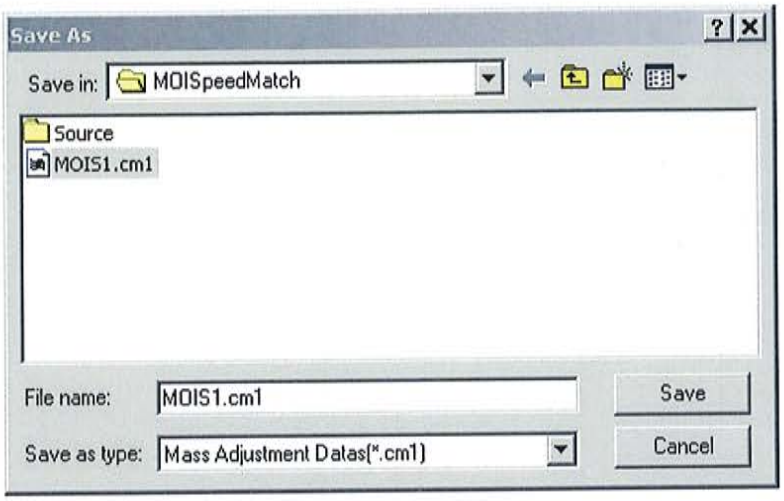
New:
Start a new file for the active module. The software will issue a prompt that it is about to start a new file. Save your work before hand or the active file will not be saved.



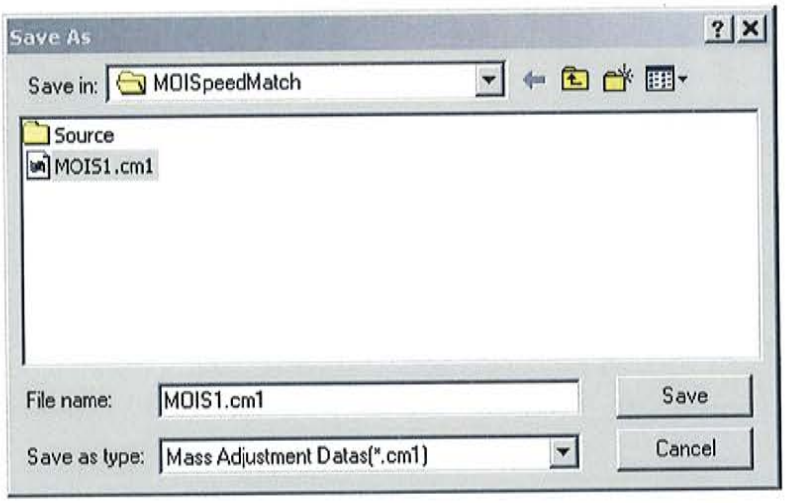
Open File:
Opens an MOi speed match file located on your drive or directory.



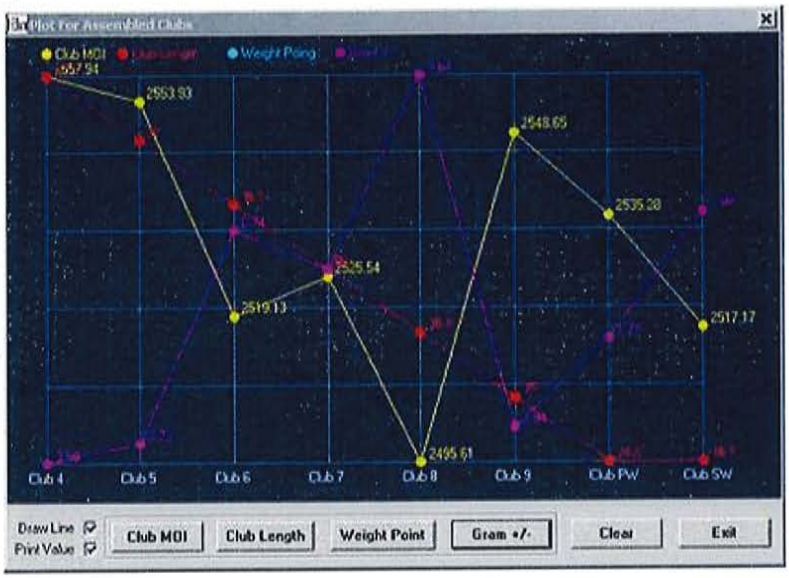
Save File:
Save a new work file your drive or directory. Type in a relevant file name and click save.
You can save your work to a different directory by clicking on the file tab.



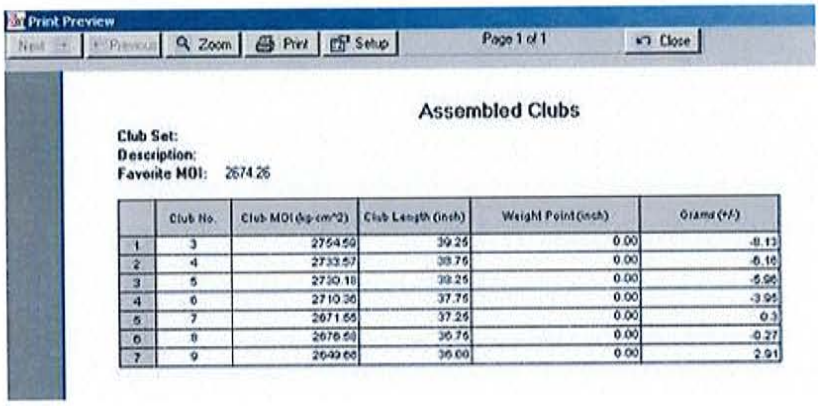
Save as:
Save the current file under a new name to a drive or directory.



Plot:
Launches the graphic representation of the data used for the MOI match
Click on the appropriate button to display the values on screen.



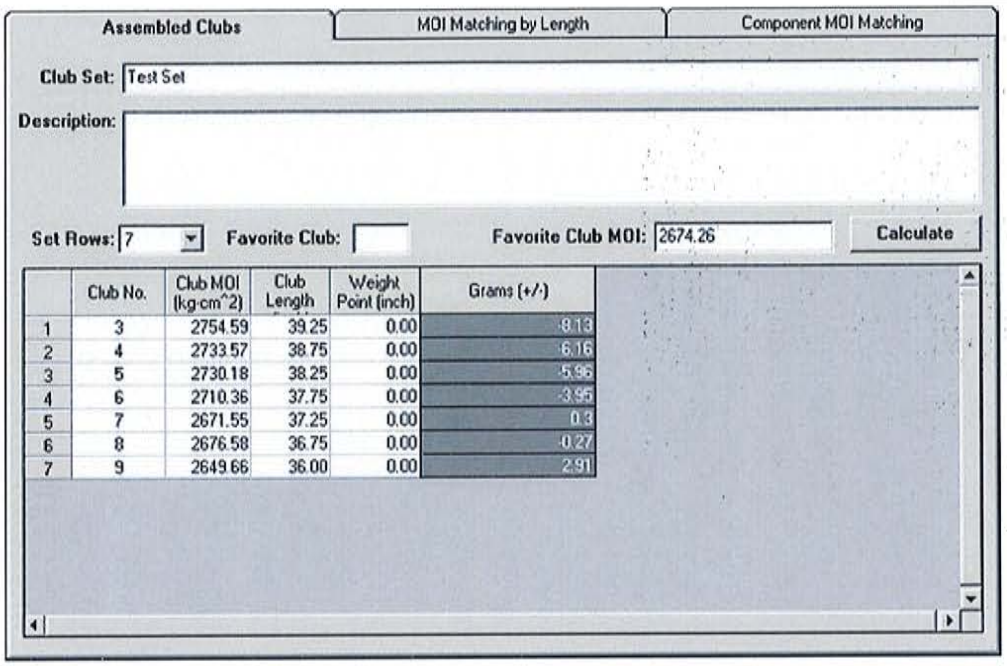
Print Preview
Launches the print preview mode for the current file. You may select the various controls, to view, zoom and print your file



5.2 Assembled Clubs Module

Previous Next

The assembled club module is primarily used for MOI matching already assembled clubs through weight adjustment only.
The data entry requirements have been kept as simple as possible to speed up the matching process .



Club Set:
This is a brief description for the set to be analyzed for an MOi match.

Description:
A detailed description of the club set along with additional details that may be usefull to the clubmaker.

Set Rows:
Activates the data entry grid and the number of rows needed is set from the tab. The number of row is limited to 12 clubs maximum.

Favorite club:
The club to which all other clubs will be matched against. While not necessary the entry is usefull for identifying the club.

Favorite club MOI:
This is the MOI of the favorite club. This value must be determined in advance using teh MOI measuring scale. The value must be in Kg-Cm^2 and must be entered into the text box as measured.

Plot:
Allows a visual representation of the data enetred into the worksheet.

Calculate
Instructs the MOI Speed Match to compute the results. The computations have to be performed each time the data in the worksheet is changed.

Club No:
This can be an alpha numeric entry that refers to the club to which the data pertains.

Club MOI Kg-Cm^2:
This is the MOI of the club as measured on the MOI scale. The value must be entered as measured.

Club Length:
The club length measured in Inches. Show Me

Weight Port:
This is where additional weights can be added to the assembled clubs. Show Me

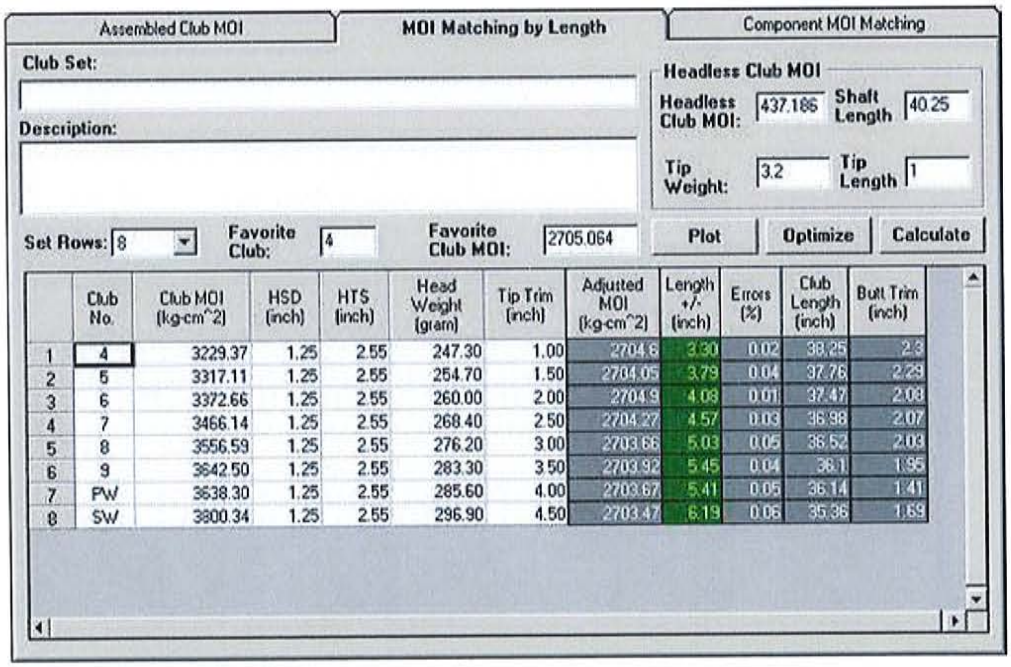
Grams (+/-):
The amount of weight that needs to be added or subtracted at the weight port to achieve an MOI match.
Please note that if the weight port value is 0, The MOi speed match will assume that weight has to be removed from the bottom of the club head sole.

5.3 MOI Matching By Length Module

Previous Next

The MOI Matching By Length Module is used when an MOI adjustment by weight is not desirable. A combination of both length and weight adjustments can be performed simultaneously for an MOI match as long as the MOI of the club that needs tuning is re-measured between weight adjustments and the value entered into the worksheet, since any weight addition to the club heads will affect the MOI of the club.

Please note: The MOI of the clubs that will be length adjusted is based on dry fitting an untrimmed shaft to each clubhead in the set and using the same grip.
Show Me



	Club No.	Club MOI (kg-cm^2)	HSD (inch)	HTS (inch)	Head Weight (gram)	Tip Trim (inch)	Adjusted MOI (kg-cm^2)	Length +/- (inch)	Errors (%)	Club Length (inch)	Butt Trim (inch)
1	4	3229.37	1.25	2.55	247.30	1.00	2704.6	3.30	0.02	38.25	2.3
2	5	3317.11	1.25	2.55	254.70	1.50	2704.05	3.79	0.04	37.76	2.29
3	6	3372.66	1.25	2.55	260.00	2.00	2704.9	4.08	0.01	37.47	2.08
4	7	3466.14	1.25	2.55	268.40	2.50	2704.27	4.57	0.03	36.98	2.07
5	8	3556.59	1.25	2.55	276.20	3.00	2703.66	5.03	0.05	36.52	2.03
6	9	3642.50	1.25	2.55	283.30	3.50	2703.92	5.45	0.04	36.1	1.95
7	PW	3638.30	1.25	2.55	285.60	4.00	2703.67	5.41	0.05	36.14	1.41
8	SW	3800.34	1.25	2.55	296.90	4.50	2703.47	6.19	0.06	35.36	1.69

Plot
Plots grphically the MOI variables for the MOI matching by Length

Optimize Show me
Unlocks the Length (+/-) column to allow manual corrections to the shaft trim for an acceptable club length increment.

Headless Club MOI Show me
The MOI of a headless club. This is the raw uncut shaft with a grip installed. The MOI is measured on teh MOI scale and the value entered as is in the relevant data entry box.

Shaft Length:
The length of the shaft untrimmed and which will be used for the set to be built. The raw shaft length must be in Inches.

Tip Weight: Show me
The weight of a tip section cut from one of the shafts to be used for the club set to be built. Weight is in grams.

Tip Length:
The length of the cut tip section in inches. Show me

Club MOI Kg-Cm^2:
The measured MOI for the untrimmed clubs. Show me

HSD:
Shaft insertion depth allias Hosel shafting depth. Show me

HTS:
Hosel to sole length allias club height. Show me

Tip Trim:
The amount of shaft tip to be removed incrementally for each club head in the set for the shaft to achieve its desired playing characteristics. If Tip trim is left blank or Zero the program will assume that the shafts are to be butt trimmed to length.

Adjusted MOI:
The Calculated MOI for each club in the set assuming that the shafts will be cut as instructed by the software. The projected MOi after trimming to length is used to determine the percentage error that will result from the trim.

Length (+/-) Show me
The calculated shaft trim that needs cutting to achive the MOI matching by length. Once the calculations are performed, the values can be adjusted manually before optimization. To adjusted the calculated values, simply clik in the cell of interest and change the trim as desired. If the Tip trim value is entered into the worksheet, the clubs will be trimmed to length at the butt.

% Error Show me
The software iterated the shaft length and calculated the moi for shaft length and compared it with the desired MOI value. When the MOI of the favorite club and the clubs to be build match to an acceptable accuracy, the amount of trim is then shown with the moi and percent accuracy between the calculated moi and the desired moi for each club. If the clubs are trimmed to the value shown, the resulting moi will be very close to that shown. You may trim at either end of the shaft but the ***total trim must equal the calculated value.***

Club Length Show me
The final club length once butt trim and tip trim are accounted for with respect to the HTS and HSD.

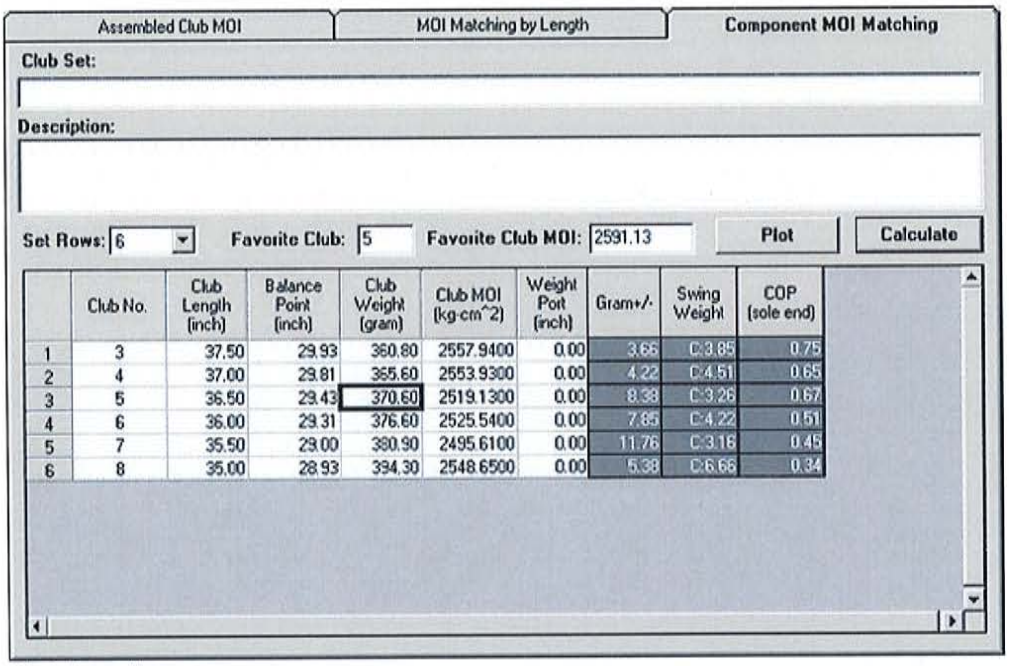
Butt Trim
The amount of trimming required from the butt end of the shaft, needed to achieve the MOI match once tip trimming has been accounted for. If the Tip trim equals zero, the butt trim and the Length (+/-) will be the same.

5.4 Component MOI Matching

Previous Next

The Component MOI matching module provides an extensive analysis for club sets to be assembled for an MOI match by weight using the dry fit assembly technic. The module can also be used with assembled clubs provide additional information for the balance point and club total weight are entered into the module.

Very Important!
The swing weight and the COP for the set are calculated for the actual clubs and not the MOI matched clubs.
If you wish to find out what the projected swing weight and COP is going to be you need to take a new set of measurement once the clubs are assembled and the data entered back into the program as a separate file.



	Club No.	Club Length (inch)	Balance Point (inch)	Club Weight (gram)	Club MOI (kg·cm^2)	Weight Port (inch)	Gram+/-	Swing Weight	COP (sole end)
1	3	37.50	29.93	360.80	2557.9400	0.00	3.66	C:3.85	0.75
2	4	37.00	29.81	365.60	2553.9300	0.00	4.22	C:4.51	0.65
3	5	36.50	29.43	370.60	2519.1300	0.00	8.38	C:3.26	0.67
4	6	36.00	29.31	376.60	2525.5400	0.00	7.85	C:4.22	0.51
5	7	35.50	29.00	380.90	2495.6100	0.00	11.76	C:3.18	0.45
6	8	35.00	28.93	394.30	2548.6500	0.00	5.38	C:6.66	0.34

Club Length:
The club length measured in Inches. Show Me

Club MOI Kg-Cm^2:
This is the MOI of the club as measured on the MOI scale.

Club Weight
The total weight of the club in grams.

Weight Port:
This is where additional weights can be added to the assembled clubs. Show Me

Grams (+/-):
The amount of weight that needs to be added or subtracted at the weight port to achieve an MOI match.
Please note that if the weight port value is 0, The MOi speed match will assume that weight has to be removed from the bottom of the club head sole.

Swing Weight
The swing weight of the clubs based on the balance point and total weight entries made into the worksheet. The swing weight is based on the 14" fulcrum scale. The swing weight is calculated for reference purposes only and has no bearing on the MOI match.

COP Sole End
This measurement refers to the center of percussion on the golf club. The lower the COP the more solid the impact with the ball and greater is the energy transfer. The dimension is given in inches with the base line at the bottom of the clubhead sole. Show me

5.5 Export Copy & Paste

Previous Top Next

The MOI speed match system is compatible with Microsft excel spread sheet and data can be transfered both ways via the clip board.

Exporting data to MS Excell
1) Select the data grid or portion of interest using the mouse Click & drag function.
2) From the Key board press **Ctrl +C** to copy the data to the clipboard
3) Start MS excell
4) Locate mouse cursor where you want the data pasted. From the **Key board** press **CTRL+V**

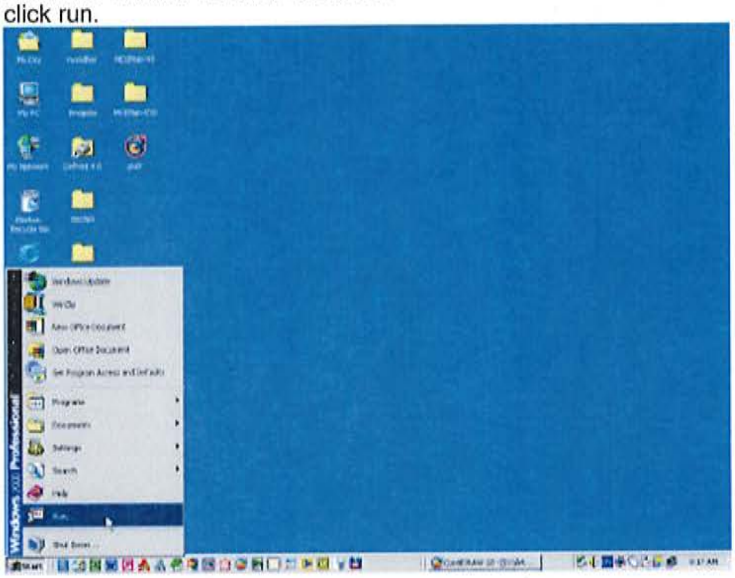
Exchanging data within the MOI Speed match system modules.
The procedure is identical. Use the CTRL+C to copy and CTRL+V to paste.

6 Installation

Insert the program CD into your computer CD loading tray. After few seconds, the program auto run installation feature will take you through the rest of the installation process.

If the auto run feature fails to load:

From the Window desktop menu bar click run.

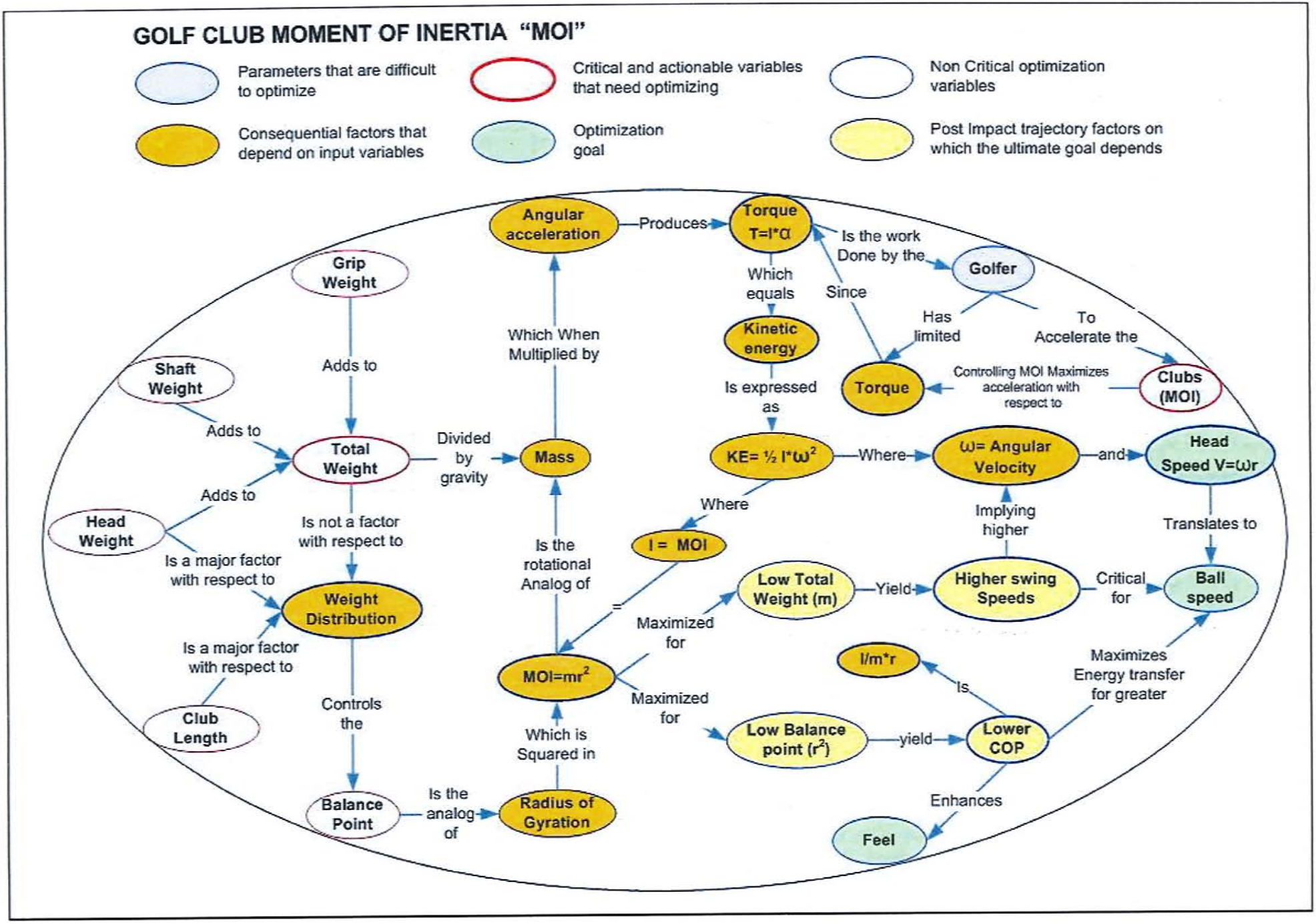


Navigate to your CD drive and select setup program icon. Click open. Follow the installation procedure on Screen.

6.1 Registration

Enter topic text here.

GOLF CLUB MOMENT OF INERTIA "MOI"



AUDITOR

MOI SPEED MATCH

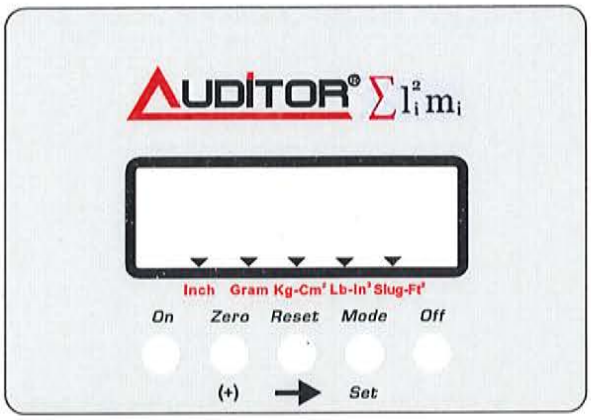
GOLF CLUB MOMENT OF INERTIA MEASURING INSTRUMENT & MOI MATCHING SYSTEM

OPERATION MANUAL
070200

Technorama Co.Ltd 781, Fong Lin Road Sec 4, Ta-liao, Kaohsiung Taiwan R.O.C
Tel:886 7643 6516 Fax: 886 7643 6529 E-mail: Sales@Golfmechanix.com
Http://www.golfmechanix.com

AUDITOR MSM

PART-1 SETUP AND INSTALLATION



KEYBOARD FUNCTIONS

ZERO Tares the display back to zero, This subtract one measurement from another to produce a net inertia measurement. Such as a gripped versus a grip-less MOI measurement.

RESET Clears the current measurement and starts the next measurement cycle.

MODE Unit selector and converter

(+) Changes selected value incrementally. Used to input calibration values, club weight and balance point when in Moi matching mode

→ Move and select on digit at a time from left to right.

Set Save input values to memory.

▼ Unit and Function indicator

Specifications

Max weight load	750 grams
Maximum moment load Factor*	6
Maximum radius of gyration**	40 inches
Minimum radius of gyration**	25 Inches
Resolution	1/1000
Maximum measurable MOI	5000 Kg.Cm²
Minimum measurable MOI***	0.005 % TI*
Accuracy	+/- 0.5%
Operating Temperature range	-20~60 C°
AC/DC adapter 9V 500Ma	

* Club balance point divided by the club total weight.(Inches and ounces or grams and mm)

** Club balance point must be between 40 and 25 inches measured from the end of the grip cap.

*** given as a percentage of the tare inertia of the system

First time operation:
Upon unpacking the Auditor MOI Speed Match its box, it is preferable not to operate the machine straight away.

1) The machine should be installed first on a wobble free, flat and level surface. The machine should be placed away from ventilation vents, direct exposure to sun light and other sources of heat and draft.

2) Even though the Auditor CGM is EMI shielded, the machine should be placed away from potential sources of electromagnetic interference such as bench grinders, micro wave ovens etc...

3) Level the machine as accurately as possible using the built in bubble level or a carpenter spirit level for greater accuracy. If the Auditor MOI Speed match is not properly leveled, inertia measurements will be inaccurate and the message bad run "B Run" will be shown on the display.

4) The Auditor MOI Speed Match is a spring Damped instrument and the accuracy depends very much on the spring linearity. To prevent damaging the damping spring the following precautions should be taken:

* Do Not overload the beam by placing on it other then conventional golf clubs of standard weight and length not exceeding 48 inches.

* Do not override the side stops that restrict the beam amplitude. Greater Angles will merely stress the spring and result in premature failure.

* When loading a club in the measuring fixture avoid excessive force to prevent twisting the beam.

5) An MOI calibration stick is provided with the machine to ensure the instrument is functioning correctly.

* Do not disassemble the calibration stick end weight
* Always tighten the two rods correctly to maintain the correct length for the stick.

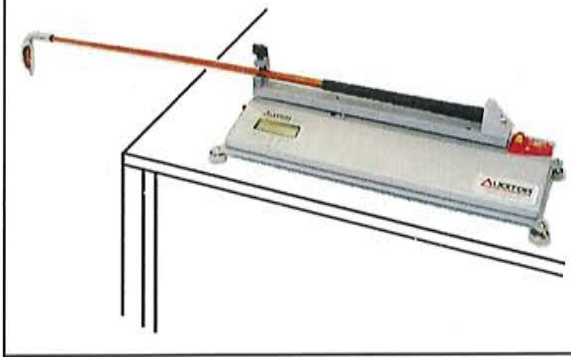
*Do not drop the calibration stick. If the end weight is marred, the MOI calibration value will be affected as a result of the change in geometry of the end weight.

* Do not bend the calibration stick and Store properly.

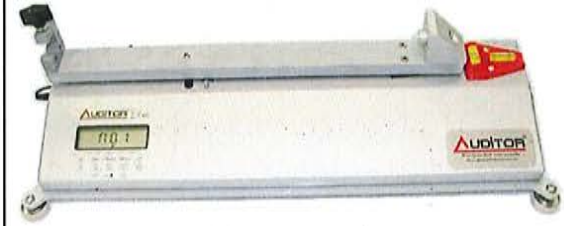
* Do not use the calibration stick for calibrating frequency analyzers, swing weight scales or similar devices.

Calibration stick
Individually calibrated. Refer to value on stick before calibrating the Auditor MSM.

PART-2 INSTRUMENT & CALIBRATION CHECK

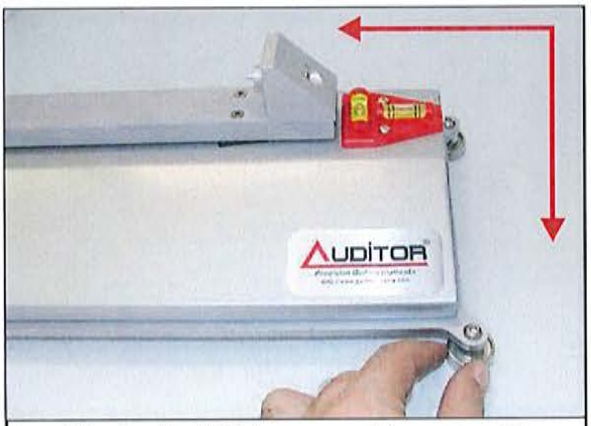


Locate the Auditor MSM on a work surface near the edge to facilitate the mounting and un-mounting of golf clubs. Enough clearance should be provided for the longer clubs.



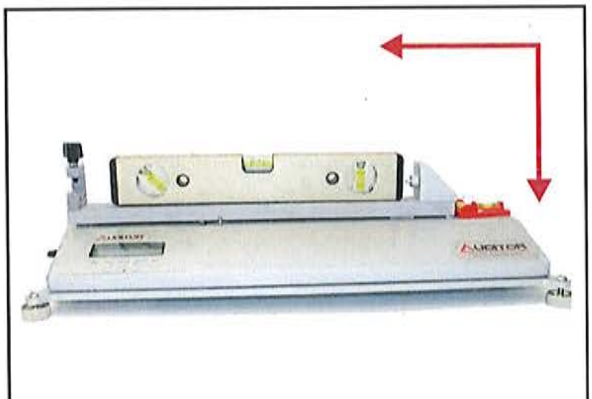
MOI
● ON

Plug in the power supply and turn the instrument to ON. The Caption MOI will show on the Display.



Level the Auditor MSM as accurately as possible using the built in bubble level. Leveling the instrument is done by dialing the leveling feet.

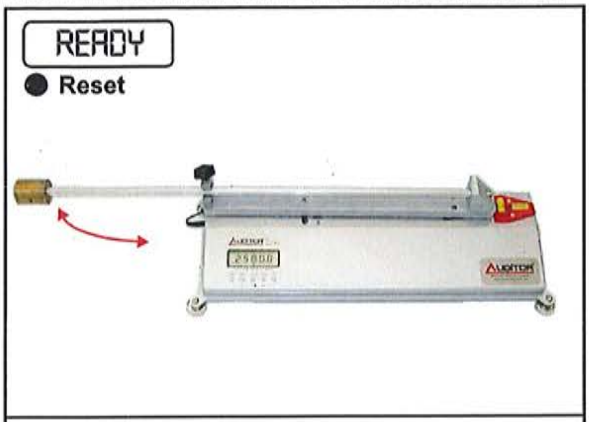
Assemble the calibration stick and tighten the two rod sections together. The Calibration value is inscribed on it for easy reference.



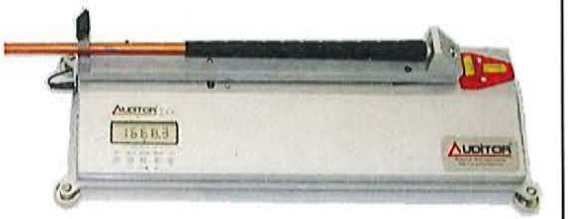
To improve the instrument accuracy, the use of a precision spirit level is recommended. Leveling must be carried out. Along the bean and across.

Mount the calibration stick on the Auditor MSM, and gently pull the beam until it contacts the side stop. Release the beam and press the reset button

PART-2.1 INSTRUMENT & CALIBRATION CHECK



The Calibration stick will oscillate gently for few seconds before the measured MOI value is displayed. Note the value mentally and press the reset button again to take a second and a third reading.



The MOI measurement is in Kg.Cm^2 by default. To convert to Lb.In^2 press MODE to toggle between the two sets of units. Slug.Ft^2 is not an available option on this instrument.

Example

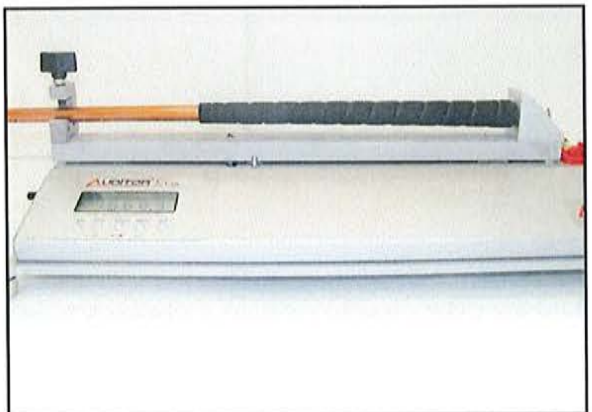
1) Mount the calibration stick on the instrument and initiate the count cycle.

RESET	2.580.0
RESET	2.580.5
RESET	2.581.5

The difference between the three consecutive readings Maxima and minima is less then 0.05% of the calibration value. When all three readings are within 1% of the calibration value the instrument is setup correctly and does not require calibration.

Important Note:

The oscillations imparted to the beam decays over time due to gravity and air friction. This introduces small errors into the measured inertia values. A maximum of three counts taken at the beginning of the cycle and at short interval are sufficient.



When placing a club on the beam it is not necessary to tsecure the club with the thumb screw, as long as the club points toe towards the ground and does not wobble during an oscillation cycle.

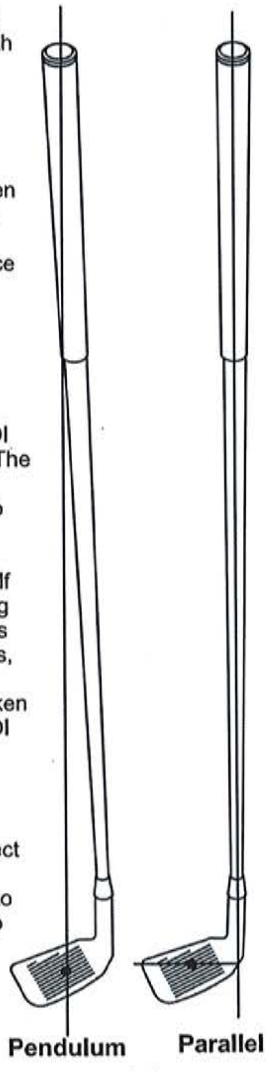
POSITIONING THE GOLF CLUB

For those club-makers familiar with MOI measurements using the pendulum method, the golf club lays on a plane controlled by The club head center of gravity. This in fact shortens the effective pendulum length which is not taken into account when calculating the inertia of the golf club using the standard pendulum equation, since the balance point of the club is measured parallel to the shaft centerline and not parallel to the pendulum plane.

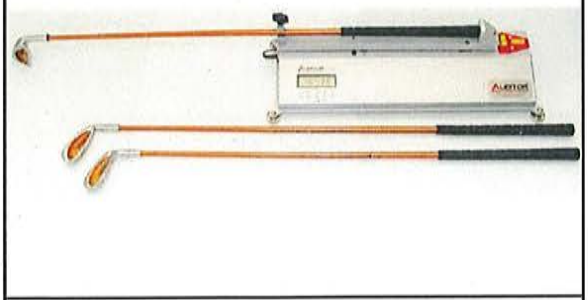
This small error in the effective pendulum length results in an MOI slightly larger then the true MOI. The effective pendulum length and experimental errors can add up to 2~3% of the effective MOI.

When measuring the MOI of a golf club using the direct method using the Auditor MSM, the golf club lies parallel to the principal inertia axis, with the club head balance point parallel to it. This fact must be taken into account when comparing MOI results gathered using the two methods.

It must be noted that when measuring the MOI using the direct method on the Auditor MSM, the reduction in golf club length due to shaft bending under load will also result in small experimental errors.



PART-3 COMPARING THE MOI OF 2 CLUBS



Mount the first club on the beam and take an MOI reading. Press **ZERO** to clear the display and remove the club. Mount the 2nd club on the instrument and take a measurement. The reading is the MOI difference.

Example

1) Mount the 1st club on the instrument and initiate the count cycle.

RESET	2.300.0	ZERO

2) Remove the 1st club and mount the 2nd club on the instrument and initiate the count cycle.

RESET	0056.0

The MOI difference between the two clubs

3) To analyze more clubs repeat step 2.
4) To exit the ZERO mode simply turn the instrument to off then back to on again.

OFF	ON	MOI	RESET	00000

Mount the second club and take a measurement. The MOI difference between the 1st club and the 2nd club is shown. If the MOI of the 2nd club is larger, the MOI difference is positive. If smaller the difference is negative.

ERR 0U

This error message is displayed when the instrument cannot compute the MOI difference between two clubs when:

1) The MOI difference between the two clubs is very small and thus exceeds the resolution of the instrument

2) The MOI value of one of the clubs that is being compared is very close or equal to the calibration MOI, which is equal the value of the calibration stick provided with the instrument.

It must be noted that the tare value MOI (ZERO) cannot equal the calibration MOI. This causes a divide by zero error and the solution cannot be resolved. When the error occurs the instrument must be re-started. To clear the tare value.

PART-3.1 MOI MATCHING OF A SET OF CLUBS

Step-1

MODE	On	MOI M

Do not release the Mode button until the function is initiated

Step-2

MODE	F MOI	MODE	00000

Step-3

Mount the favorite club on the Auditor MSM. When done pull the beam against the side stop and release the beam gently. Press **RESET** to start the count cycle.

1639.5

Step-4

MODE	MOI 2	MODE	00000

Mount the club that needs MOI matching on the instrument. And initiate a count cycle.

RESET	00000	1638.1	MODE
M LOC	MODE	00.00	

Inch

Use the **ZERO** and the **RESET** key to enter the Distance in inches from the grip end to where additional weight can be added or removed from the club head. For this example additional weight can be located 32 inches from the grip down the shaft.

32.00	MODE	0.40

Gram

In this example an MOI match between the favorite club and the club that needs matching requires that 0.40 grams be added 32 inches from the grip end.

Step-5

To match additional clubs to the favorite club MOI repeat **step-4.** If you wish to terminate the MOI matching mode turn the instrument to **OFF**

PLEASE NOTE:

1) The Standard units for when in MOI matching mode are Kg.Cm^2, Grams and inches. It is not possible to convert to Lb.In^2 or ounces.

2) The **reset** key can be used any time during a measuring cycle to Interrupt the cycle or to re-take a 2nd measurement for verification purposes. Pressing the mode key will automatically save the last measurement to memory for further computations.

MATCH

When one of the clubs to be MOI matched has the same Moi as the favorite golf club the caption "Match" will appear on the display. Press **MODE** to resume MOI matching another club in the set.

ENTERING THE MASS LOCATION (Inches only)

To input the distance from the grip end to where additional **can be added or removed from the club head use the ZERO** and the **RESET** key as follows:

ZERO (+)	Each press will increment the active digit by one from 1-9
RESET-->	Each press will activate the next digit to the right.

PART-4 AUDITOR MSM CALIBRATION

The Auditor MSM requires calibration at regular intervals. The procedure assumes that the instrument is properly leveled. Prior to calibration, ensure that the instrument is still, since outside factors such as wind draft may interfere with the calibration. The calibration stick should be inspected and the calibration value known before initiating the procedure.

Step-1 (zero Reset Mode must be pressed down simultaneously and hold while pressing the On button. Do not release the zero reset mode buttons for at least 10 seconds. until **Cal P1** is displayed.

ZERO	RESET	MODE	On	CAL P1

Step-2

MODE	00000

Step-3 Pull beam and release gently (**Do not place the calibration stick on the beam**)

Step-3-1

RESET	00000	0.2660
RESET	00000	0.2660
RESET	00000	0.2660

All three readings should yield the same result +/- 1
If the results do not agree. Repeat **step 3** through 4
If the results agree proceed to next step.

Step-4

MODE	CAL P2

Step-5 Place the calibration stick on the beam.

Step-6

MODE	00000

Step-7 Pull beam and release gently

Step 7-1

RESET	00000	1.3037
RESET	00000	1.3038
RESET	00000	1.3040

All three readings should yield the same result +/- 3
If the results do not agree. Repeat **Step 7.**
If the results agree proceed to next step.

Step-8

MODE	C MOI
MODE	2580.0

This is the calibration stick value as set at the factory.
If the calibration stick value matches the value displayed proceed Press **Mode** To finish. The instrument will shut down and restart automatically.
If not proceed to **Step 8-1**

Step-8-1

MODE	C MOI
MODE	2580.0

If the Instrument MOI calibration value and the calibration stick value do not match proceed as follows:

ZERO (+)	Each press will increment the active digit by one from 1-9
RESET-->	Each press will activate the next digit to the right.

Finish entering the MOI calibration stick value, as directed.

Step-9

MODE	MOI

The instrument will shut down and restart automatically

Step-10

With the calibration stick still on the beam.
Pull the beam gently against the side stop and release.

RESET	00000	2579.5
RESET	00000	2580.0
RESET	00000	2580.5

All three readings should yield the same result within 1%. The Auditor MSM is now calibrated.

You may wish to continue working or you can turn off the instrument. The settings will not be lost.

Remark

During the calibration procedure it is not possible to skip between settings and the procedure must be followed exactly as directed.

If a step is missed, the calibration procedure must be repeated all over again.