Many of the tips published here have, in one way or another, required a 'feeling' for where the Center Of Gravity on your bike is. No manufacturer, however, publishes that information and, of course, the CG changes based on how heavy the rider is, how he sits in the saddle, and how luggage is loaded. How, then, can one determine where the CG is on their motorcycle?

I will present here a method for you to determine with a high degree of accuracy where the location of your CG is and ask in return that if you follow this procedure you send me the results. I am trying to build a database of 'typical' results and would greatly appreciate your feedback.

There are two configurations that are of interest: with and without a rider. Given measurements for both configurations you can rather easily predict the consequences of adding a passenger or unusual luggage.

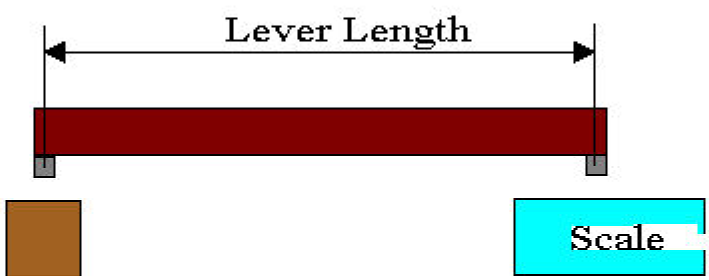
You will need to be able to measure weights and distances. Thus, you will need a scale and a tape measure. A bathroom scale will work just fine, even if you need to weigh something heavier than it is calibrated to measure.

The easiest dimension to find is where the Center Of Gravity lies relative to your wheelbase. You will recall that on a level surface the total weight of your bike is distributed onto both wheels in direct proportion to where the CG lies on your wheelbase. If, for example, the CG was directly over your front tire then 100% of the weight of the bike would be on the front tire and there would be no weight on the rear tire. If the CG was 55% of the distance along the wheelbase from the center of the front-wheel contact patch to the center of the contact patch of the rear wheel, then 55% of the total weight of the bike would be on the rear tire and only 45% on the front one.

From this fact we see that in order to find the horizontal location of the CG all we have to do is determine the weight on each tire. Similarly, we now know how to use a bathroom scale to measure those weights, even if they exceed the limits of the scale.

We need to place a board between the scale and a surface the same height as the scale, and place the wheel we want to weigh somewhere on that board. By measuring the length of the board and where the tire rests on it at the time of the measurement, we can convert what the scale tells us is the weight into what it really weighs.

For example, let us say that the length of the board from the point one end of it touches the scale to the point the other end touches what it is resting on is 24 inches. (You might add small 1x1" pieces of wood to your board at each of these contact points to insure accuracy of your measurements.)



Before you place the wheel on the board note the weight on the scale. Let's say it shows 2 pounds. You then place the front tire on the board and measure the distance from the point the board contacts the scale to the center of the contact patch of the tire. Let's say that turns out to be 10 inches. 10 divided by 24 is .417, thus, 41.7% of the weight of the wheel will be on the end of the board away from the scale and 58.3% will be on the scale itself.

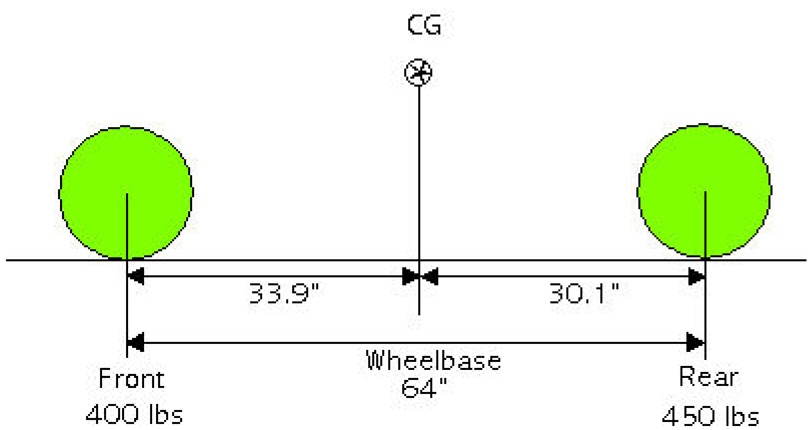
In other words, if the scale shows a weight of 152 pounds, then the actual weight of the wheel is (152-2)/.583 = 257 pounds.

So, now it's time to determine the horizontal location of the CG. Measure the weight of the front wheel and then the weight of the rear wheel (without a rider on the bike.) The total weight of the bike is then merely the sum of these two weights.

If, for example, the front wheel weighs 400 pounds and the rear wheel weighs 450 pounds then the total weight of the bike is 850 pounds.

Now you need to measure the length of the wheelbase. This is the distance between the center of the front-wheel contact patch and the center of the rear-wheel contact patch. (Your owner's manual will list this length for you.)

From the above we have learned that 52.9% of the weight of the bike is on the rear wheel (450/850). Thus, the CG must be 52.9% of the wheelbase from the FRONT tire's contact patch. If the wheelbase is 64", then the CG must be located slightly less than 34" from the front contact patch (64 * .529 = 33.856).



Repeat the measurements with a rider in the saddle. You will find that the Center Of Gravity has moved towards the rear of the bike.

Measuring the height of your CG is a great deal more difficult to accomplish. It is difficult for most people even to visualize. The process involves lifting the rear-end at least 1 foot off the ground and then measuring the weight of the front wheel.

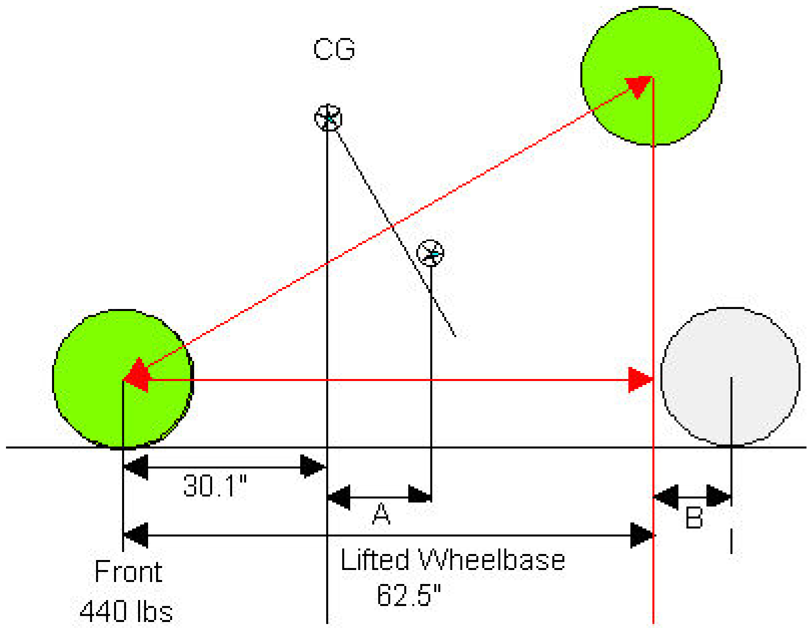
Let me describe a couple of things that should help explain why this will tell us how high the CG is.

When you lift the rear-end you are shortening the wheelbase. That is, the horizontal distance between the contact patches is physically shorter than when the bike is level. (If you lifted the rear-end so that it was directly above the front wheel the wheelbase would be reduced to zero.)

If the Center Of Gravity happened to be located at exactly the height of the wheelbase (actually, if it was at the height of the front wheel hub) then its relative location along the wheelbase would remain constant. It would continue to be at 52.9% of the wheelbase away from the front contact patch. That is, whether the bike were level or not the weight on the front wheel would remain the same.

However, if the CG is higher than the front wheel hub then lifting the rear-end will cause it to move disproportionately closer to the front wheel contact patch. If, for example, the CG was located 1 mile above the bike, then lifting the rear-end of the bike only a few inches would cause the CG to move so far forward it would actually be well forward of the front wheel. Your CG is not located 1 mile above the bike, but it is located higher than the hub of your front wheel. Thus, it will move disproportionately towards the front wheel as you lift the rear one.

In other words, if we lift the rear wheel the front wheel will get heavier and the rear wheel will get lighter. ***<u>The higher the CG is relative to the height of the front-wheel hub, the heavier the front-end will become for any given lift of the rear wheel</u>***.



The diagram above shows the rear-end of a motorcycle lifted off the ground and what effect that has on the movement of the Center of Gravity towards the front of the bike. The diagram shows a lift considerably greater than 1 foot in order to clearly demonstrate the concepts described.

By simply weighing the front wheel and measuring how high we have lifted the rear-end we can calculate all other measurements, including the height of the CG above the ground. Please note that because the CG is higher than the hub of the front wheel (around which we pivoted the lifted bike) it has shifted towards the front of the bike distance 'A' which is considerably greater than the shortening of the bike's wheelbase ('B'). (Had the CG been at the same height as the front-wheel hub then distance 'A' would have been only about 50% of distance 'B'.) In other words, the front-end of the bike must have gotten heavier as a result of lifting the rear-end of the bike, and **<u>the amount of added weight on the front-end is a function of how high the CG is relative to the height of the front-wheel hub</u>**.

We will use a little trigonometry to calculate what the height of the CG must be simply by determining how much weight has been added to the front wheel while the rear-end of the bike is lifted. Not to worry, I will give you a formula that is easy to perform in order to get the results. Even easier, at the end of this article I have provided an Excell Model that will do all the calculations for you.

Please note that you will probably require at least one other person to help you with these measurements.

When you lift the rear wheel you do so in one of two ways: you rest the rear tire on a raised surface or you lift the rear wheel via jacks located on the rear wheel hubs. What you cannot do is lift the bike with a jack located anywhere else.

These are the measurement you will need:

L1 = Length of wheelbase while bike is level
H1 = Height of front hub off the ground
H2 = Height of rear wheel hub above the front wheel hub (how high the rear-end has been lifted).
W1 = Weight of front wheel when bike is level
W2 = Weight of rear wheel when bike is level
W3 = Weight of front wheel when bike is lifted

Wt = Total bike weight = W1 + W2
Wf = Weight added to front wheel because of lift = W3 - W1
Ln = New wheelbase = Sqrt(L1^2 - H2^2)

Assuming you have lifted the rear wheel at least 1 foot (the measurement is more reliable if you can lift it higher), then the height of the CG is found with the following formula:

Height of CG = H1 + (Wf * L1 * Ln) / (Wt * H2)

Let's do an example.

Assume we have made our measurements as follows:

L1 = 64"
H1 = 13"
H2 = 14" (We lifted the bike 14")
W1 = 400 lbs.
W2 = 450 lbs.
W3 = 440 lbs.

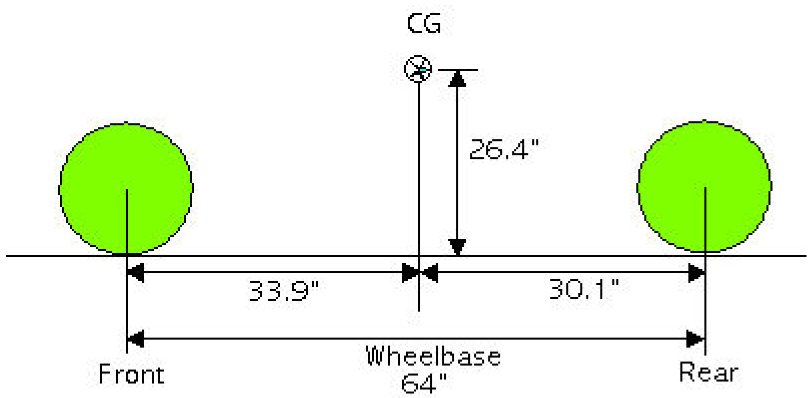
From these numbers we calculate:

Wt = 850 lbs. = W1 + W2
Wf = 40 lbs. = W3 - W1
Ln = 62.45" = sqrt(64*64 - 14*14)

Plugging the numbers into the formula we get:

H = 13" + (40 lbs * 64" * 62.45") / (850 lbs * 14")
H = 13" + 159,873 / 11,900
H = 13" + 13.43"
H = 26.43"

The CG of the driverless motorcycle has been found to be about 26 1/2 inches above the ground and about 34 inches behind the contact patch of the front wheel.



When you repeat these measurements with a rider in the saddle you will find that the CG moves towards the rear and gets higher.

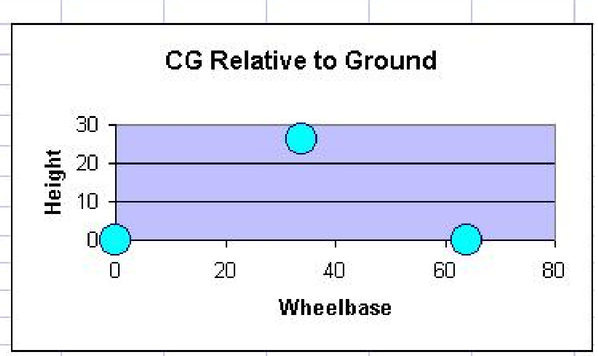
I know this is a lot of work and that not many of you will be interested in doing that work because, after all, knowing exactly where your Center Of Gravity is located does not make for a safer ride. But having a feel for where it is and what happens to it when the bike is carrying luggage/passenger or if it is not perfectly level *IS* one more bit of understanding that cannot be worthless in your quest for that safe ride. For any of you that do perform these measurements I ask again that you send me the results.

Thank you.

Below is an example of a Model Calculator for use by those of you with Excel to do the calculations described.

Center Of Gravity Calculator

Length of level wheelbase	64	in
Height of front wheel hub	13	in
Height of rear wheel off ground	14	in
Weight of level front wheel	400	lbs
Weight of level rear wheel	450	lbs
Weight of front wheel when rear is lifted	440	lbs
Total weight	850	lbs
Weight added to front wheel by lift	40	lbs
Wheelbase when rear wheel is lifted	62.45	lbs
Horizontal location of CG	33.88	in
Vertical location of CG	26.43	in



Cells with a border outline are the input data