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# Formulation of Ready to Use Program to Evaluate Center of Gravity of Go-Kart and Automotive 4WD Vehicle

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**Abstract—***A go-kart is a specially designed vehicle for entry level racing competition. It has got no differential and no suspension. It is an on-track vehicle which is made for the rider to learn driving in a completely safe place. It is one of the milestone young racer needs to achieve it before entering into the world of professional racing. As we can see, that design of go-kart is of much important for the safety of the driver and for other purpose. Since the co-ordinates of center of gravity is directly related to the performance of the vehicle, we are going to focus on the calculation of center of gravity for a go-kart vehicle. We have to determine the location of center of gravity to find out individual wheel loads in steady-state cornering, accelerating or during braking. We have iterated the calculation of center of gravity process a multiple times considering weight of the vehicle to be different in each case to get the exact height of the center of gravity. We have assumed and calculated the center of gravity during the static condition of the vehicle. We have iterated the calculations in a c++ program with variable list given in Table 1. We have also shown the algorithm used in the program along with the flowchart for better understanding of the program***.**

## 1. INTRODUCTION

Go-Kart is a small four wheeled vehicle designed for only track based purpose. It is also called karts and gearbox/shifter karts which is completely dependent on the vehicle design. It is generally considered as the first step towards the racing career. Popular racers have started their career in karting. It has got no differential and no suspension. The reason for not having differential as the kart is very small in size while it is used only on-track, so it has got no suspension as well. Art Ingels is considered as the father of karting. It was first originated in the year 1956 and then it was spread to other continents like Europe. A go-kart is a track focused vehicle designed for track based purpose. Now, there are various companies available which has commercialized the production of go-kart vehicle.

One of the most important parts of the vehicle is to calculate the Center of gravity. It helps to determine individual wheel loads in steady state cornering, braking or in accelerating condition. There are various ways to calculate the position of the center of gravity. We have used the theoretical approach to easily get the value of center of gravity. However, we have considered certain assumptions for exact position of the center of gravity and to remove any kind of complicacy of the system. We have considered all the calculations in steady state of the vehicle and all the variables used in this calculation are in equilibrium condition. Another assumption we have used is that we have considered basic dimensional data like front and rear wheel track, wheelbase of the vehicle and height of the center of gravity are constant. If the dimensional changes are quite large, then we have to make use of the iterative procedure to reach the exact desired value. The last assumption we have considered is the roll cage of the entire vehicle is rigid. This is so because the torsionally stiff chassis is desirable for effective and lenient calculations.

## 2. THE VARIABLES USED FOR CALCULATION

We have shown all the variables as shown in table number 1. The name of the variable along with its designation is given. We have also used the variables in the images as shown in figure 1 and figure 2 for proper understanding of the design procedure and method of calculation. So, if we follow these images then we will be able to relate to the actual data or variable used in the program. These variables as described in the table below are used to create the algorithm, given later part of the program.

**Table 1: List of Variables Used in the Program.**

| Variable | Designation |
|---|---|
| w | Total weight of the vehicle (lb) |
| wdf | Front Weight Distribution |
| wdr | Rear Weight Distribution |
| l | Wheel Base |
| tf | Front Wheel Track |
| tr | Rear Wheel Track |
| theta | Inclination Angle |

| | |
|---|---|
| wf | Front Wheel Total Weight |
| wr | Rear Wheel Total Weight |
| w1, w2 | Front Wheel Total Weight Equal Distribution |
| w3, w4 | Rear Wheel Total Weight Equal Distribution |
| a | Distance Between Front Wheel And Center Of Gravity Of The Vehicle |
| b | Distance Between Rear Wheel And Center Of Gravity Of The Vehicle |
| d | Difference Between tf And tr Equally Divided Between The Two |
| y1 | Distance Between Rear Wheel Center Line And Center of Gravity |
| y2 | Distance Between Center of Gravity And The Center Line |
| l1 | New Inclined Height |
| rl | Rolling Radius |
| b1 | Distance as shown in figure |
| c | Distance as shown in figure |
| h | Distance as shown in figure |
| h1 | Distance as shown in figure |

## 3. IMAGES USED FOR CALCULATION

Here is the image used for better understanding of the calculation, flowchart and algorithm. We have shown here two figures. Figure 1 represents horizontal location of total vehicle and figure 2 represents vertical location of the center of gravity. The images are actually used and had been referred for the calculation of the Center of Gravity and also for formulation of the program which calculates the Center of Gravity.

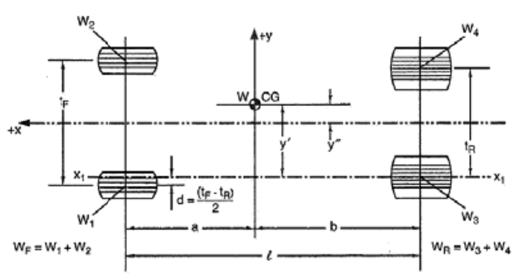


**Figure 1. Horizontal Location of Total Vehicle of Center of Gravity.**

We have used another to show the location of center of gravity when the rear set of tires are lifted up. The image is shown below.

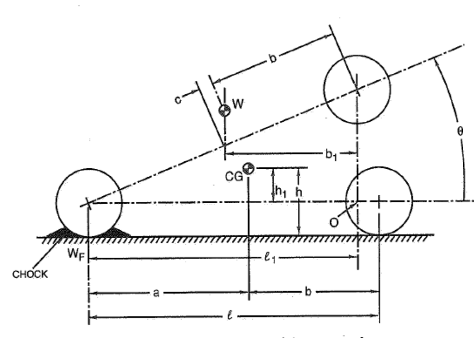


**Figure 2: Vertical Location of the Center of Gravity**

We have used both the images for better understanding of the position of assumed variables. The designation of all the variables are given in Table 1. These variables are used in the program to get the actual result of the required co-ordinates of the location of Center of Gravity.

## 4. ALGORITHM OF THE PROGRAM

We have shown below the stepwise algorithm of the program for in-depth analysis of the program.

Step 1:

Start

Step 2:

Declare wdf, wdr, w, l, tf, tr, theta, wf, wr, w1, w2, w3, w4, a, b, d, y1, y2, l1, rl, b1, c, h, h1.

Step 3:

Take input for the variables of wdf, w, l, tf, tr, theta and rl.

Step 4:

Subtract wdf from 100 and assign the value to wdr.

Step 5:

Calculate front weight (wf) of the vehicle from the equation wf= (wdf/100)*w.

Step 6:

Divide equally the front weight load on each vehicle by the equation w1=w2= (wf/2).

Step 7:

Calculate the rear weight (wr) of the vehicle from the following equation wr= (wdr/100)*w.

Step 8:

Divide equally the rear weight load on each vehicle by the equation w3=w4= (wr/2).

Step 9:

Determine the value of the variable b from the equation b= (w1+w2)*l/(w).

Step 10:

Subtract b from l and assign the value to a.

Step 11:

Subtract tr from tf and then divide it by 2, to assign the value to d.

Step 12:

Calculate y1 with the help of equation y1= (w2*(tf-d) + (w4*tr)-w1*d)/w.

Step 13:

Calculate y2 with the help of equation y2= y1-(tr/2).

Step 14:

Multiply l and cos(theta) and assign the value to l1.

Step 15:

Calculate b1 with the help of equation b1= wf*l1/w.

Step 16:

Find the value of c with the help of c= (b1/cos(theta))-b.

Step 17:

Calculate h1 with h1= (wf*l-w*b)/(w*tan(theta)).

Step 18:

Add h1 and rl to assign the value to h.

Step 19:

Display a, b, y1, y2, l1, b1, c, h and h1.

Step 20:

Stop.

## 5. THE FLOWCHART OF THE PROGRAM

The flowchart used in the program is shown below. It shows the design methodology of the program.

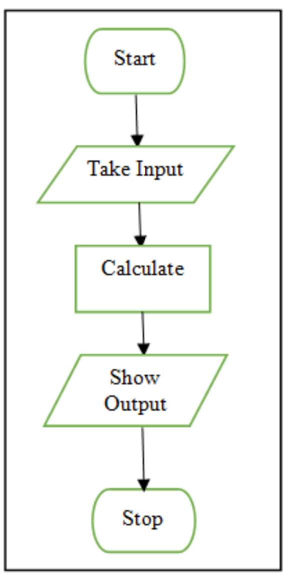


**Figure 3: The Flowchart of the Program.**

## 6. THE ASSUMED SITUATION

The input and the output screen are given below. We have assumed the following situation.

Front Weight Distribution- 45%

Total Weight of the Vehicle- 2000 lbs.

Wheel Base l- 8 ft.

Front Wheel Track- 0.9 ft.

Rear Wheel Track- 1 ft.

Inclination angle- 0.2025 rad.

Rolling Radius- 1.2 ft.

### The Input and the Output Screen

We have given the input on the above situation on our program. The input screen is given below in figure 4 and the output screen is given in figure 5.

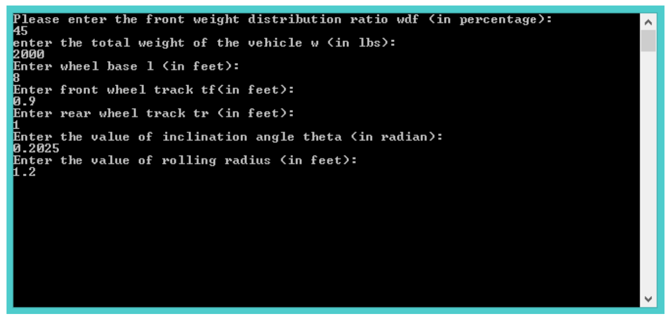


**Figure 4: The Input Screen.**

With that being given the input, the output screen is given below.

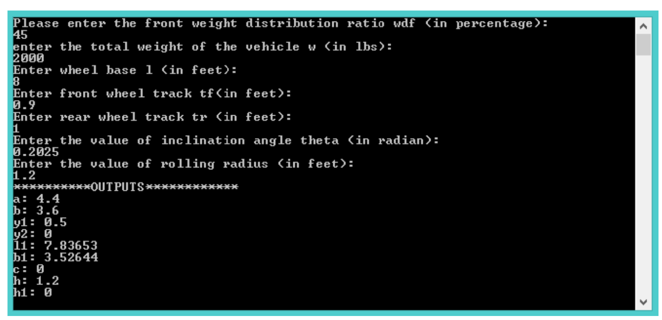


**Figure 5: The Output Screen.**

## 7. THE RESULT OF OUR ASSUMED SITUATION

From the output screen, we can derive the following result:

1. Distance between front wheel and center of gravity of the vehicle- 4.4 ft.
2. Distance between Rear Wheel and Center Of Gravity of the vehicle- 3.6ft.

3. Distance between Rear Wheel Center Line and Center of Gravity- 0.5 ft.
4. Distance between Center of Gravity and the Center Line- 0 ft.
5. New Inclined Height- 7.83653 ft.
6. b1- 3.52644 ft.
7. c- 0 ft.
8. h- 1.2 ft.
9. h1- 0 ft.

## 8. THE CONCLUSION

The calculation of Center of Gravity of the entire vehicle is one of the most important parts for tweaking the handling performances of the vehicle. It is used for determining braking, steady-state cornering and accelerating condition of the vehicle.

Since, the performance of the vehicle depends on a lot of design changes, its generally advisable to go into iterative process. This is where computer programs come into play. These programs are made just to take input from the user and show output saving a lot of our time from tedious calculations. We have to keep on changing a single value and need to check the actual result. By the end of this process we are going to get the actual result of the location of the Center of Gravity.

We have tested the program in multiple platform and we have achieved desired result. We have tested the program to find the Center of Gravity on vehicles like All-Terrain-Vehicle and for super sports vehicle like the vehicles manufactured for Supra SAE India. So, we can conclude that this program can be applied in all the vehicles to calculate the co-ordinates of Center of Gravity.

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