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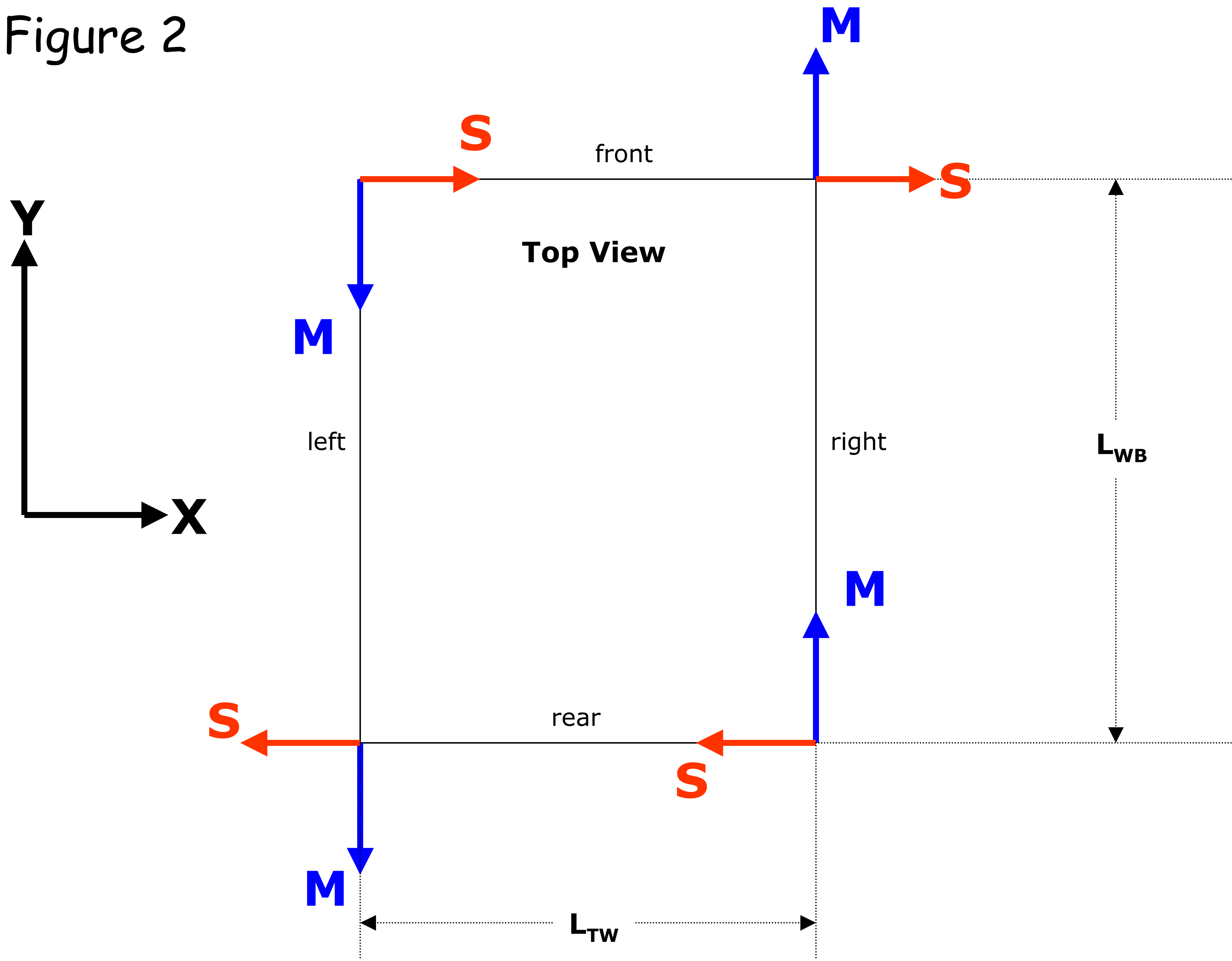
Figure 2



See Figure 2 on previous page.

- rectangular (non-square) wheel pattern (trackwidth<>wheelbase)

- all four wheels identical

- CoM located at CoA

- coefficient of static friction equal in all directions

- same torque magnitude (but opposite direction) driving each side

The vectors M and S on the diagram are the Y and X components, respectively, of the net force that the carpet is exerting in the XY plane on the bottom of each wheel.

The magnitude of M is equal to the driving torque being applied to the wheel divided by the radius of the wheel.

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Proceed as follows:

1. **By symmetry, all four M forces are equal to each other in magnitude, and all four S forces are equal to each other in magnitude.**

2. **To be in equilibrium, the net torque acting on the vehicle must be zero around any point. To simplify the math, select the front right wheel as the point. Then $2*S*L_{WB} = 2*M*L_{TW}$ => $S=M*(L_{TW}/L_{WB})$. Define $f_2= L_{TW}/L_{WB}$ => $S=f_2*M$**

3. **The magnitude of the net force on each wheel is $F=sqrt(M^2+S^2)=M*sqrt(1+f_2^2)$**

4. **From symmetry, the normal force N is the same at each wheel, so N=W/4 (where W is the vehicle weight).**

5. **To break the static equilibrium and start the vehicle moving, F must be greater than mu*N: $F > mu*N$ => $M*sqrt(1+f_2^2) > mu*W/4$ => $M > mu*(W/4)/sqrt(1+f_2^2)$**

6. **The vehicle will turn when $M > mu*(W/4)/sqrt(1+f_2^2)$, which means the torque on each wheel must be greater than $radius*mu*(W/4)*sqrt(1+f_2^2)$**

Notice that when f_2 equals 1, the solution above reduces to the solution for Scenario1