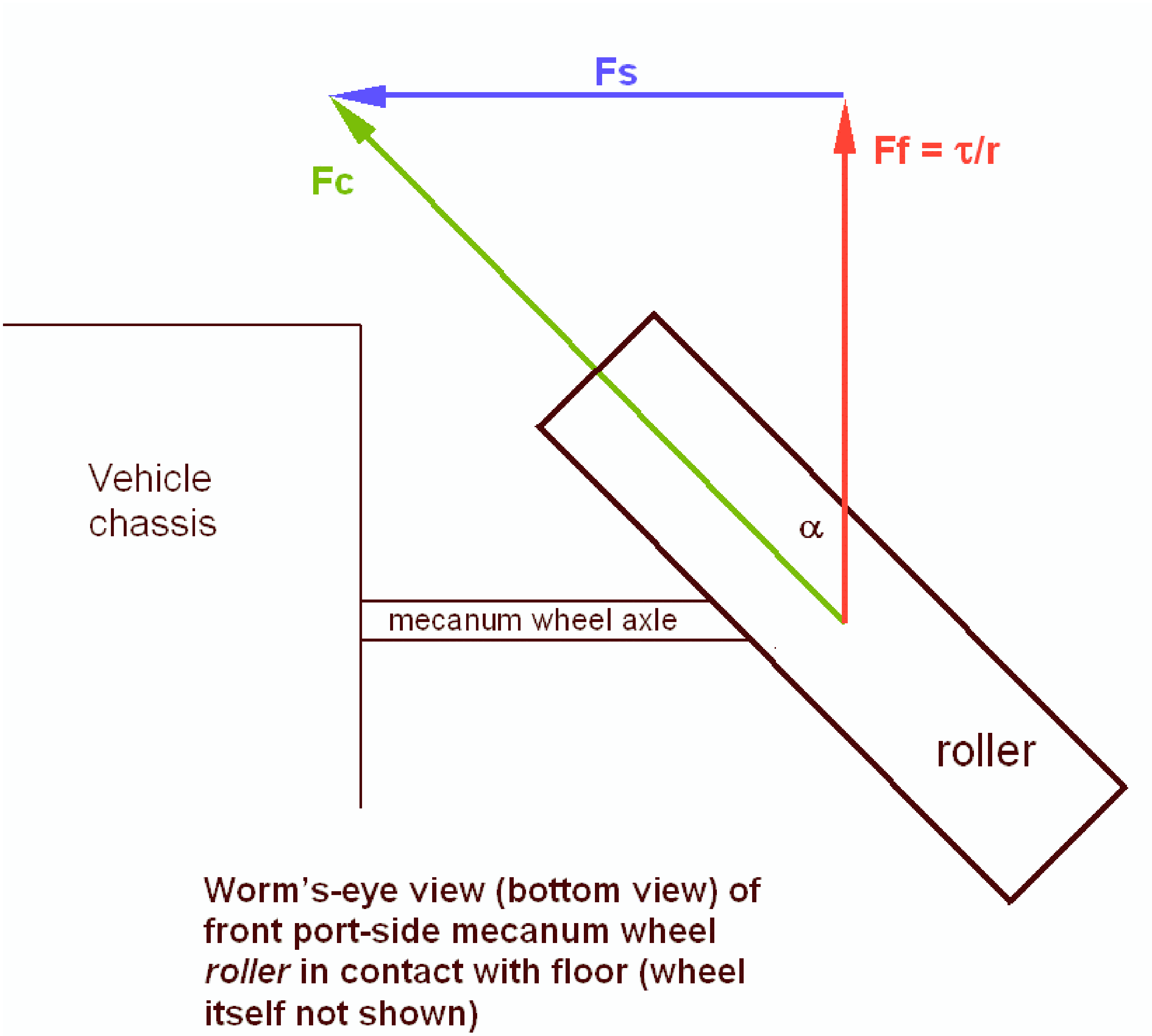


This paper explains why a mecanum-wheeled vehicle has less traction (and thus less "pushing force") than a standard-wheel vehicle, even if both vehicles have the same motors, drivetrain, weight, and tread material.

Figure 1 below shows a "worm's-eye" view of the roller of the front port-side mecanum wheel of a vehicle with four mecanum wheels. The vectors are drawn for the wheel being driven in the "forward" direction.



The green vector Fc is the reaction force of the floor on the bottom of the mecanum roller which is in contact with the floor. Assuming no friction in the roller bearings, this force *must be aligned along the roller axis* (assuming the roller is not accelerating).

Fc has two components, Fs and Ff.

Fs is counterbalanced by an equal but opposite force from the wheel on the other side of the vehicle (when that wheel is being driven with the same torque). This would be the case when the vehicle is to be driven straight forward.

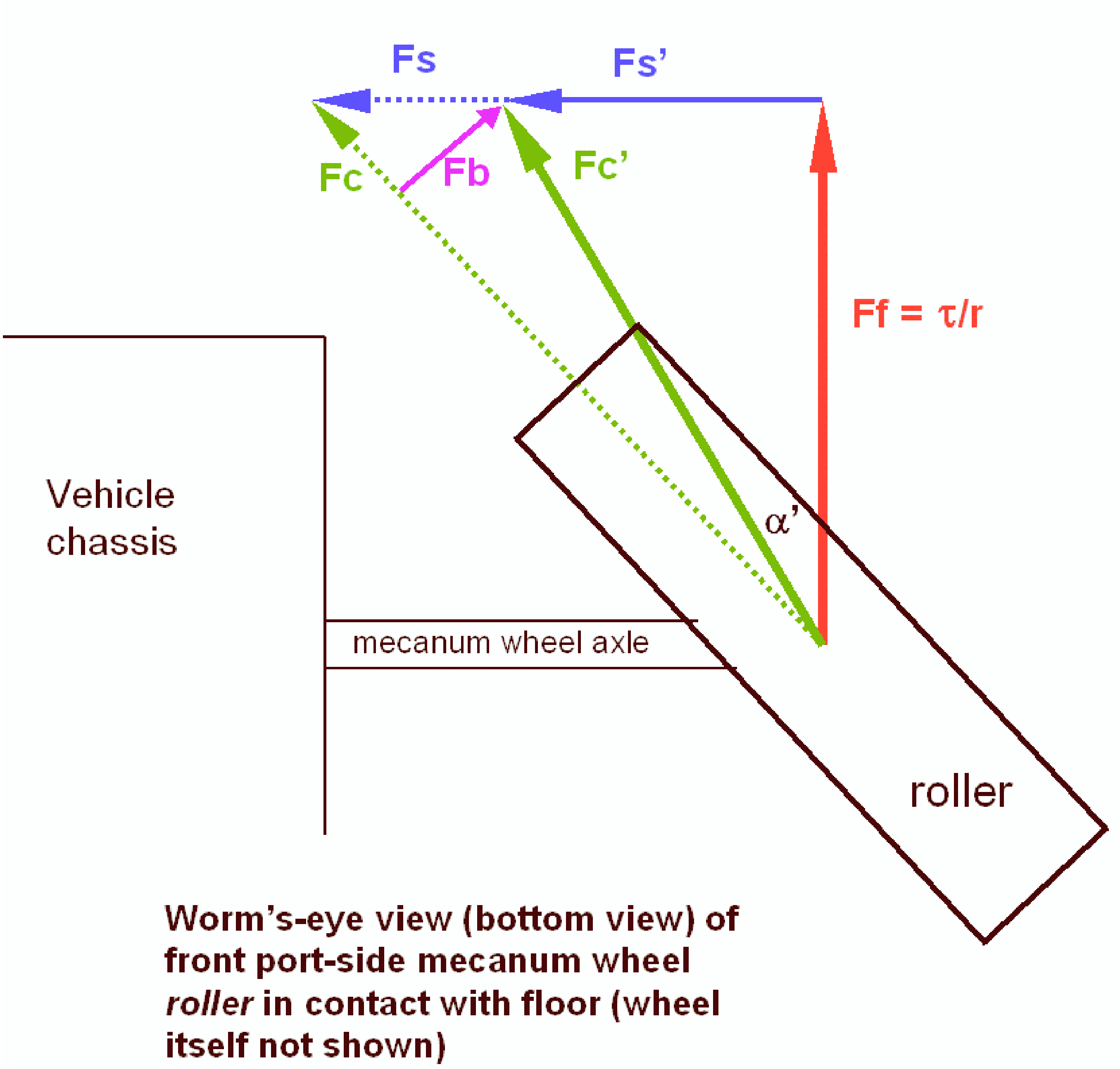
Ff is the forward component and is *in the plane of the mecanum wheel*. Assuming the wheel is not accelerating (constant or zero speed of the vehicle), *the net torque on the wheel must be zero*. Therefore Ff must be equal to τ/r, were "τ" is the driving torque applied to the mecanum wheel, and "r" is the radius of the mecanum wheel. The torque r•Ff counterbalances the driving torque τ, for a *net torque of zero on the wheel*. This in turn implies that Fc must equal Ff/cos(α).

Note that the forward force Ff provided by this mecanum wheel *is the same as the forward force that would be produced by a "standard" wheel of the same diameter being driven with the same torque*; but in the case of the mecanum wheel the reaction force of the floor on the wheel (roller) is greater by a factor 1/cos(α). *It is this greater reaction force which causes the mecanum wheel to break friction with the floor and slip at lower forward-force levels than a standard wheel*. This explains why a mecanum vehicle has less traction than a standard-wheel vehicle, *even if they both use the same wheel material*.

Now consider the case where the vehicle is strafing toward starboard (to the left in Figure 1 since it is a bottom view).

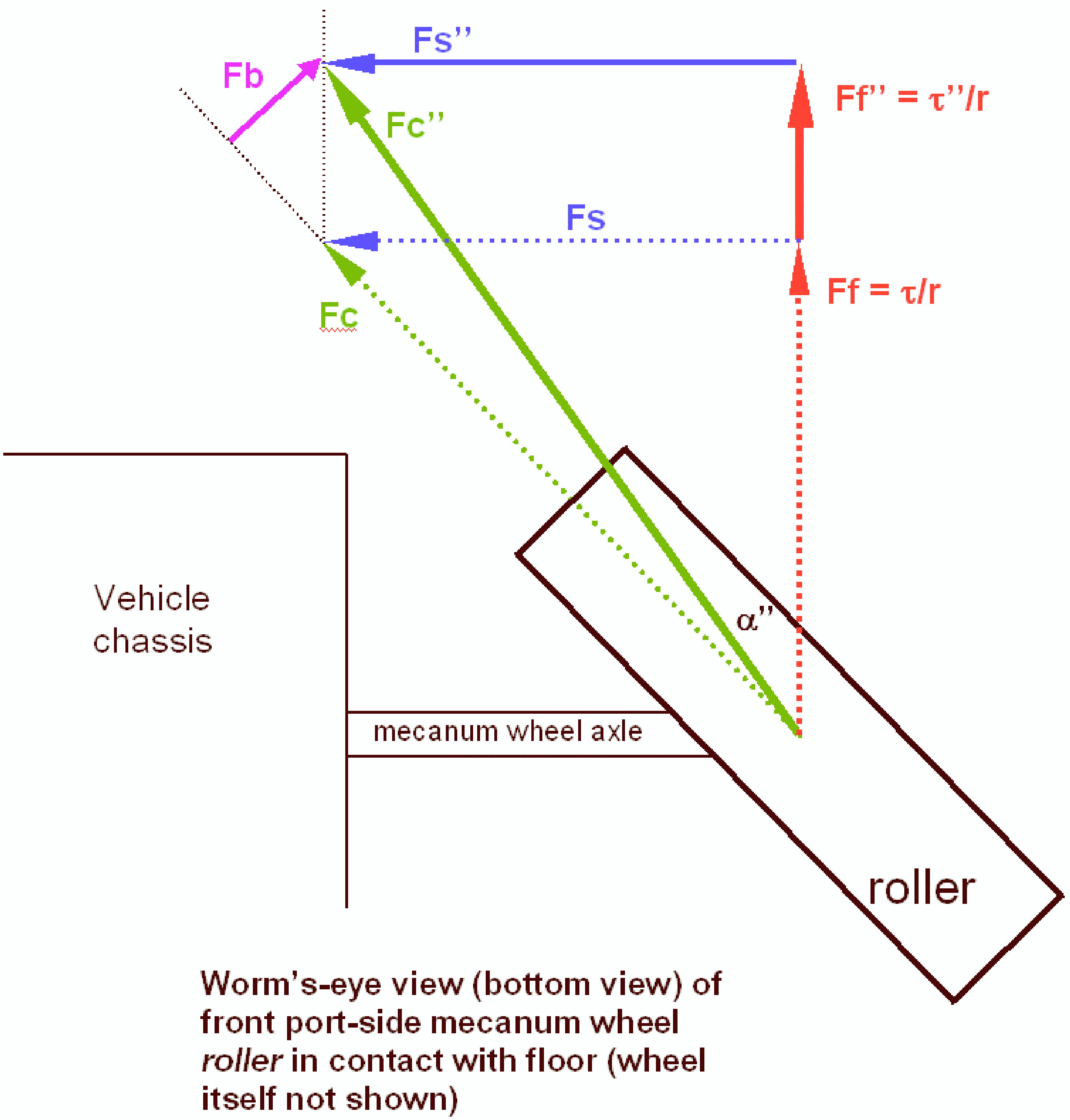
When strafing, the rear port-side wheel is driven with the same magnitude of torque as the wheel shown in Figure 1, but in the "backwards" direction. Ff in Figure 1 is counterbalanced by an equal but opposite force from the back wheel of the vehicle. Fs will be in the same direction for the front and rear wheels and, for a 45 degree roller angle, it will have the exact same magnitude as Ff. Therefore, assuming no roller bearing friction, the "pushing force" (and speed) of the vehicle is the same in the fore/aft and sideways directions.

Note that the green vector Fc acting along the axis of the roller will slide the roller along its axle until all the free play has been taken up and the roller encounters something to prevent further axial movement. If this "something" is, for example, a ball bearing, friction will be minimized. Otherwise this contact, especially if it is rubber-on-metal, will create friction. This friction affects the analysis, as shown in Figures 2 and 3 and ensuing discussion on the following pages:



The vectors shown in dotted lines are there for reference only. The forward-force vector Ff remains unchanged; it must still equal τ/r. A new vector Fb has been introduced due to the roller bearing friction. The introduction of the Fb vector reduces the angle and magnitude of the Fc vector; it is now Fc'. The reduced magnitude of Fc' means that greater forward force Ff can be applied (by increasing the driving torque) before the roller breaks friction with the ground. This gives the mecanum wheel greater traction (in the fore/aft direction). <u>Roller bearing friction improves traction in the fore/aft direction.</u>

In the sideways direction, the Fs magnitude has been reduced to Fs' by the introduction of roller bearing friction Fb. For the same motor-driving torque as the friction-free case, the available sideways pushing force has been reduced (from Fs to Fs'). This means that the motor torque must be increased from τ=Ff•r to τ''=Ff''•r (see Figure 3 below) to obtain the same sideways driving force Fs'' as the friction-free case Fs. The necessary increase in motor torque to get the same sideways force as the friction-free case also increases the reaction force to Fc'' so that it is greater than the friction-free reaction force Fc. <u>Roller bearing friction reduces traction and available force in the sideways direction.</u>



On a final note, please note that the vector force analysis for an "omni" wheel (a wheel with rollers mounted along its circumference with axles in the plane of the wheel and tangent to the wheel's circumference) is different. Omni wheels, unlike mecanum wheels, are mounted at a 45 degree angle to the fore/aft axis of the robot.