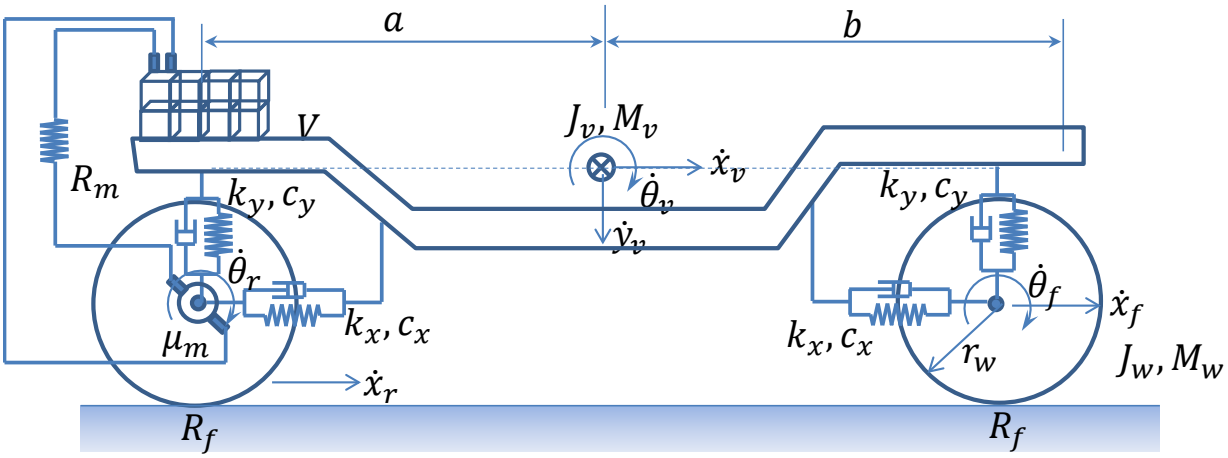
Systems and Control: Assignment 1

The schematic representation of a DC motor driven railway bogie is shown in the figure. The wheels are perfectly rigid and the track is perfectly flat, so there is no vertical excitation from the rail on the wheels and the wheels have no vertical velocity. Note that this is not coach or car-body; the coach is mounted on two such bogies with another set of secondary suspensions (air springs) placed in the V-grooves.

The following are the details of this system: V is a constant supply voltage from a battery pack, μ_m is DC motor characteristic constant and R_m is armature resistance, k_x and c_x are, respectively, the large horizontal stiffness and damping of the primary suspension, k_y and c_y are, respectively, the soft vertical stiffness and damping of the primary suspension, the mass and rotary inertia of each wheel are M_w and J_w, respectively, the mass and rotary inertia of the bogie body are M_v and J_v, respectively, the friction at rail-wheel contact is nonlinear and is represented by a damping function R_f, a, b and r_w are the geometric dimensions, as shown. The coordinate system to be used is shown in the figure.

Assume small rotation and that the height of bogie c.g. from the suspension fixation points is small. Further consider gravity is acting downward on the bogie body (it is not useful for the wheels because those have no vertical degrees of freedom). Then neglecting horizontal velocity at suspension fixation point (due to pitch of the vehicle), but considering that due to bogie body velocity alone, draw a bond graph model of the system. Scan all the formulations and the model, and upload as single pdf file.



Hints:

1. The rear wheel is driven by the DC motor and generates a forward traction force. This force is transmitted through the horizontal suspension stiffness and damping to the bogie body and is then applied to the front wheel. In front wheel, there is no motor and hence wheel rotates because of the push from the bogie body. The slip in rear wheel is positive and in front wheel is negative.

2. The motor is mounted on the bogie body and applied a torque on the rear wheel. Thus, a reaction torque must act on the bogie body. In absence of vertical excitation from the track, the bogie heave and pitch are due to the reaction torque from the motor.

3. Consider 1-junction for bogie x-velocity and model bogie inertia there. This 1 junction should be coupled to the 1-junctions for wheel horizontal velocities for transmission of traction force through the horizontal suspensions. Note that in reality, both x and y suspensions are the same unit having stiffness and damping in all three directions, with lowest stiffness in the vertical direction.