Guidelines for Drawing Free Body Diagrams (FBDs)

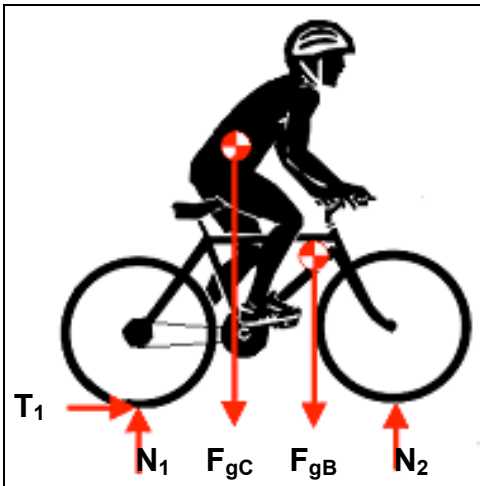
Importance of Proper FBDs

Free Body Diagrams (FDBs) are an important tool in engineering analysis and a cornerstone of systematic implementation static and dynamic analysis for many machine design calculations. I believe that about **80% of errors** in machine design calculations are due to incorrect FBDs, which lead to inaccurate equations and analysis.

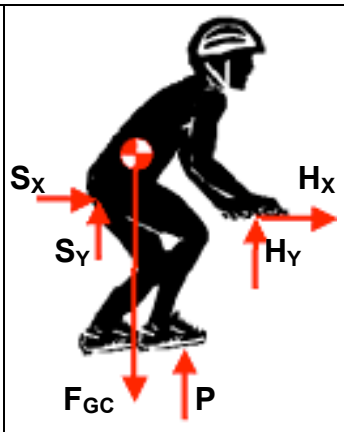
What is a FBD?

A FBD is a drawing of an object or system of objects that shows all vector forces and moments applied onto that object. Below is an FBD of a system consisting of a bicycle with rider. Note that all forces shown are the external forces acting on the system, and the force vectors are drawn in the direction in which they are applied onto the system. By drawing forces properly the equations of motion and/or equilibrium directly correspond to what is shown in the FBD.

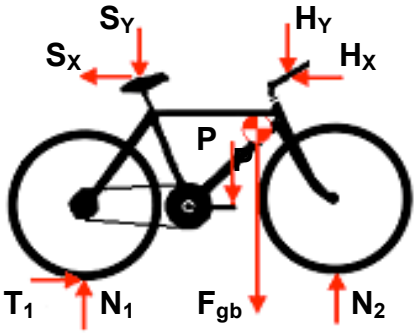
Forces that are internal to the system being analyzed are NOT shown. For example in the FBD of the **Cyclist on Bicycle**, pedal forces are not shown since they are internal forces. However in the **FBD of the Cyclist** the pedal forces are shown, since they are external forces applied onto the Cyclist. Note, that the Pedal forces are an equal and opposite force in the **FBD of the Bicycle**, since contact forces always have an equal and opposite reaction force.



FBD of Cyclist on Bicycle



FBD of Cyclist



FBD of Bicycle

F_{gC}	Cyclist gravity force	P	Pedal Force
F_{gB}	Bicycle gravity force	S_X	Seat Force – X
T_1	Traction force	S_Y	Seat Force – Y
N_1	Normal force 1	H_x	Handlebar Force – X
N_2	Normal force 2	H_Y	Handlebar Force - Y

Bicycle example inspired by Statics: Analysis and Design of Systems in Equilibrium by Sheppard and Tongue