*x*

*y*

F3

F1

F2

F0 (93 lbs.)

*c*

L1

L2

L3

D = 2.17’

*x*





Note: Forces are just weights (gravity is ignored as it will simply cancel out anyway)

F1, F2, F3 are the forces (weights) for the three robots

L1, L2, L3 are the lengths from the center of the climb bar (*c*) to where the robot attaches to the bar

F0 is the force (weight)) for the climb apparatus itself which has a center of gravity 2.17’ below the top and has a weight of 93 lbs which is labeled as D

θ is the angle that bar tilts at equilibrium

Δx is the displacement along the x axis when the bar is tilted at angle θ

Each Force will exert a torque T which are equal to … Note that the side that is tilted upwards has a minus sign and the side that is tilted downward has a + sign. This can be determined by finding which is greater F1L1 or F2L2 + F3L3 with the smaller value getting a minus sign and the heavier side a + sign.

|T1| = F1L1cos - F1Dsin

|T2| = F2L2cos + F2Dsin

|T3| = F3L3cos + F3Dsin

|T0| = F0Dsin

At equilibrium (the bar is not moving, but not necessarily horizontal) the absolute values of the torques subtracted from one another will equal 0.

|T1| - |T2| - |T3| - |T0| = 0

(F1L1cos - F1Dsin- F2L2cos - F2Dsin -F3L3cos - F3Dsin-F0Dsin

rearranging we get …

cos F1L1 -F2L2 -F3L3) – sin (F1D + F2D + F3D + F0D)

cos / sin = (F1L1 -F2L2 -F3L3) / D(F1 + F2 + F3 + F0)

 = tan-1 [(F1L1 -F2L2 -F3L3) / D(F1 + F2 + F3 + F0)]