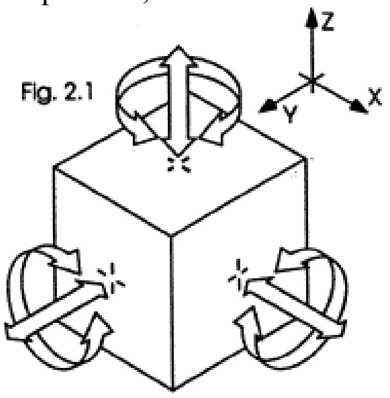
Lab 6: Kinematics and Constraints

It is essential that we understand how to constrain our systems in order for the system to perform. Allowing only the minimum number of degree of freedoms to vary will reduce cost, improve stability, and allow for easier alignment. For a 2D system, there are 3 DoF (x, y, θ_z) that can vary while for a 3D system, there are 6 DoF (x, y, z, θ_x, θ_y, θ_z). During this lab, you will be investing different constraints and setups explained both in class and in Blanding's paper and explore different kinematic mounts and how they can be used to control and define motion of a system. Our 2D systems will consist of manila envelopes, thumb tacks, and push pins. For our 3D objects, magnetic balls and joints, glue gun and dowel rods will be used. You can talk with you partners, but this is an individual lab.

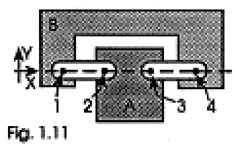


<u>Constraint and overconstraint</u>

For a 2D object, remove a single DoF using both a link and a post
(Does it matter how long or where along the constraint line the constraint is applied?)

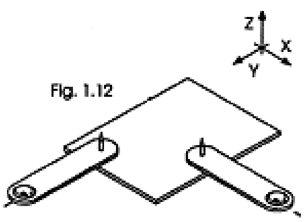
For the same object, overconstrain the object by adding another constraint along the same line.
(What problems occur from over constraints?)

Create Figure 1.11, but make 2 & 3 a little long.
(Is this setup overconstrained? How would you constrain it in all three DoFs?)



<u>Instant Center of Rotation</u>

Create this device (Figure 1.12)



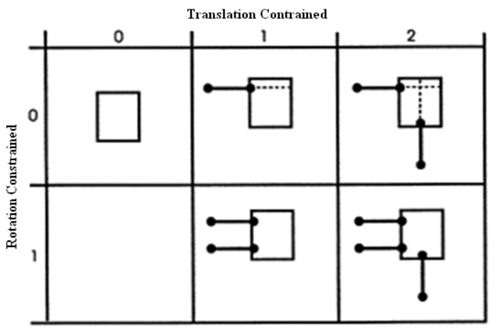
(How many DoFs are constrained? What is not constrained? Where is its reference?)

Try varying the lengths of the links. Change where you pin down the links.
(What happens to the center of rotation?)

Fully constrain the object by adding a third link.
(Can this be added anywhere?)
(you want to maximum each of the moment arms that this 3rd constraint forms, i.e., you want to create an isosolyse triangle with the connectors of the links to the solid body)

Make the links parallel to each other.
(What happens when the links are parallel?) (hint, the center of rotation is at infinity)
(Where would you add a tangent bar for this setup?)

Make each diagram below (skip what you have done) and describe what is constrained and what is free.



Cascading Constraints
Create a Drafting Machine.
(How many constraints are there?)
(If there are more than 3 constraints, is this device overconstrained? Why or why not?)
(Where is the point we care about on the object and what DoFs are free?)

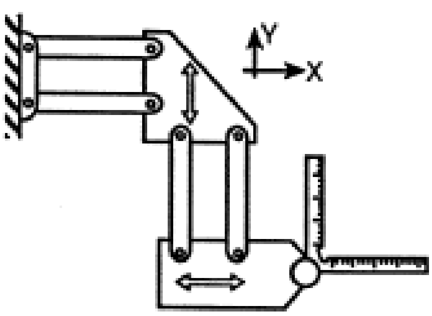
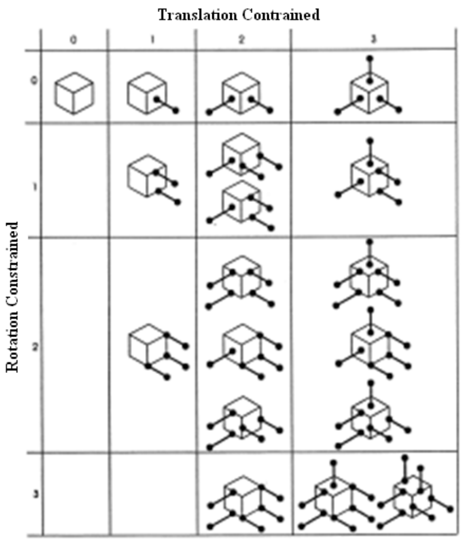


Fig. 1.38

3-D Constraints

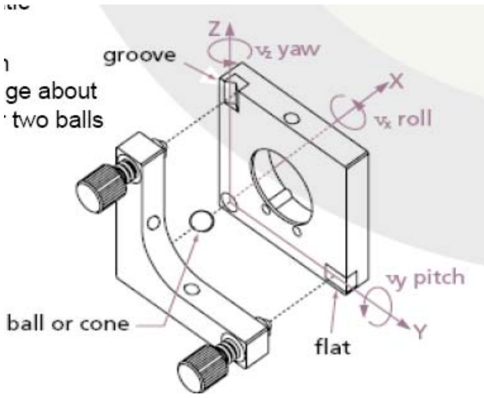
Using the aluminum cubes and the dowel rods, make these 3D models. Constrain all 6 DoFs for the cube, but note the movement of the object after each constraint is added.

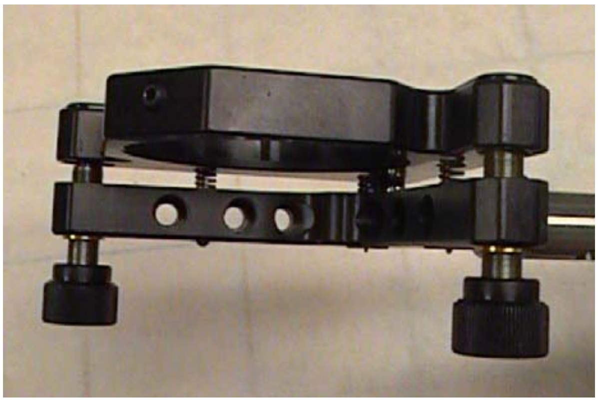
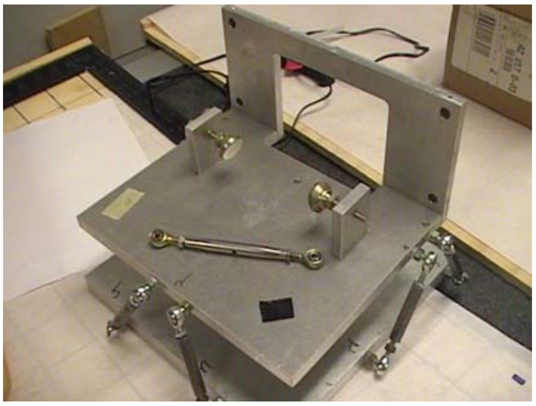


Can you think of other ways to constrain the 3D object? What if you had additional datum? Create another object using 2 datums.
Create another object using 3 datums.

Understanding Kinematic Coupling

For kinematic structures in the tub, draw a schematic of each one. Note which DoFs are constrained and which ones are not.



For the hexapod mount, try to find how to move it in all six DOFs. How the pods are made?

Rigid Bodies

Create a 3D rigid body using the B=3J-6 equation. Compare to a non-rigid body of the same structure.

Use the magnetic tools build up rigid structures. (Does what you built match the equation?)

Add up joints, keep the structure stable. (Do you overconstrain it?)

Take away one of the bars. (How the body become unstable?)