**Two-Dimensional Forward Dynamics**

**Dynamically driven**

nc < nq

 does not have full row rank

cannot solve kinematics only 

given 

compute 





must use forward time integration of  to get  at next time step

**Differential-Algebraic Equations (DAE)**

differential equations for dynamics 

algebraic equations for kinematics 

**Kinematics**

generalized coordinates  size nq x 1, nq = 3 (nL-1)

constraints  size nc x 1 nc = nk + nd

Jacobian  size nc x nq

**Inverse dynamics**

nc = nq for kinematically driven problem

know driver motion at **any time** t, find 

position solution 

velocity solution  size nc x 1



acceleration solution  size nc x 1



constraint forces 

**Forward dynamics**

use initial conditions for  and integrate forward in time using small increments

solve kinematics and dynamics simultaneously 

insufficient constraints to fully control mobility 

Jacobian not full row rank  nc < nq

EOM matrix has full row rank 

**example** four bar mechanism with M=1 and no kinematic driver defined

nq = 9 but nc = 8

same size 

smaller 



must know     at current time step

can compute   at current time step

use DAE to find  and  

no drivers  no driver forces 

integrate  to predict  at next time step

**example** five bar mechanism with M=2 and no kinematic drivers defined

nq = 12 but nc = 10







no drivers  no driver forces 

**example** five bar mechanism with M=2 and one kinematic driver defined

nq = 12 but nc = 11

same size 







one driver  one driver force 