General Procedure for Velocity and Acceleration

NOTE: NO EVALUATION until step #2!

1.) Describe the system and motion: (order A-C depends on problem information):

A) Define the position:
- Define enough reference frames to clearly describe the position
- The position vector should not contain any trig elements (this is what basis transformation are for!)
- example: $\vec{r}^{\,p/o} = L_1\hat{a}_1 + L_2(t)\hat{c}_3 + R(t)\hat{w}_2$

B) Describe the motion:
- Points, frames, rotations, translations, position vector, relative motion, or constraints on motion, paths
- Identify knowns/unknowns, DOF

C) Write the definition of velocity with respect to the frame you wish to calculate the derivative in using proper notation:

$$^N\vec{V}^P = \frac{^N d}{dt}(\vec{r}^{\,P/O})$$

- **Always Verify** this definition, point "o" is fixed in "N"
- If you are using recursive formulas, write the equations you will be using now:
  Using points in the body:
  - Write the position vector in terms of each intermediate point to get to the final point
  - Identify the frames/bases used between each point
    - Identify each rotation/translation between points
  - Starting at the first point, write down the recursive formula.
    - Evaluate, repeat for the next point
      - In general this will require all angular velocities (and all angular accelerations for acceleration)

  OR defining "translations" by grouping all the terms in the position vector that have the same basis

2.) Evaluate/Solve:

1.) Using the direct derivative
- Transform the entire position vector to the basis you are taking the derivative in
- Apply the simple derivative to the measure numbers

2.) Using the kinematic derivative
- Use the kinematic derivative to evaluate each term in the position vector
  - In general this will require all angular velocities

3.) Using the recursive equations for velocity and acceleration evaluate the cross products

Tips for understanding motion:
- Draw separate pictures for each body/point to understand their motion
- Examine at an arbitrary point in time

When in doubt - write it out!, When in doubt - try it out!

Constrained problems:
1.) calculate the velocity of a common point with different position vectors
2.) utilize path variables if the motion is not easily described with standard reference frames
3.) utilize the expressions for rolling contactsl

- Constraints/Rolling: Ignore the contacts/constraints at first - calculate velocities without thinking about the constraint, then add constraint relationship