**Degrees of Freedom (DOF):** Min # of parms needed to fully specify config

**Displacement:** diff between initial and final location

**Distance:** Length of path traveled

**Speed** is just a scalar value where velocity has direction

Area under accel curve gives change in vel

Area under vel curve gives disp

A screenshot of a computer screen

Description automatically generated

A diagram of a motorbike

Description automatically generated

A close-up of a number

Description automatically generated

A table with math equations

Description automatically generatedA diagram of a mathematical equation with Ice hockey rink in the background

Description automatically generatedA diagram of a mathematical equation

Description automatically generated

The sum of mr2 for all the particles of mass in a solid is called the moment of inertia. Rod held on the end is (ML2)/3

**Parallel axis theorem:** Calculate MOI of body around axis: IP = Icm = Md2

A math equation with red text

Description automatically generated with medium confidence

A math equations and formulas on a white background

Description automatically generated

A black text on a white background

Description automatically generatedA mathematical equations and formulas

Description automatically generatedA math equations and formulas

Description automatically generated with medium confidenceA mathematical equation with numbers and symbols

Description automatically generatedA diagram of a bicycle

Description automatically generatedA drawing of a straight line

Description automatically generatedThe group of all rigid motions (*R*,*d*) is known as the **Special Euclidean group**, *SE*(3)

A diagram of a cylinder with a straight end and a straight end with a straight end and a straight end with a straight end and a straight end with a straight end and a straight end with a

Description automatically generatedA math problem with a triangle and a triangle with text

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Axis angle forumulas

A screenshot of a math equation

Description automatically generatedA white paper with text and black text

Description automatically generated with medium confidence

A white background with black text

Description automatically generated

A screenshot of a math game

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Description automatically generatedA math equations and formulas

Description automatically generated with medium confidence

**Center of mass:** Point at which the three axes of rotation intersect

Parallel axis theorem for rotations: Io = RIRT

**Non inertial reference frame:** undergoes accel wrt an inertial frame

**Fictitious force:** force that appears to act on a mass whose motion is described by non inertial ref frame

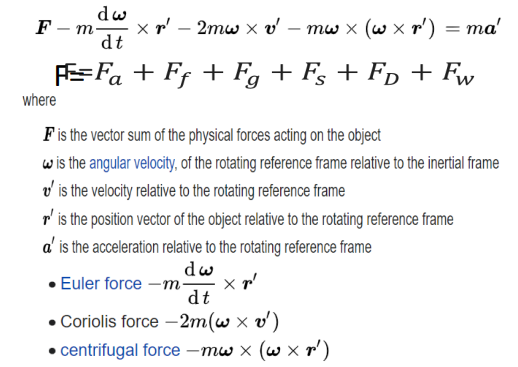
A diagram of a mathematical equation

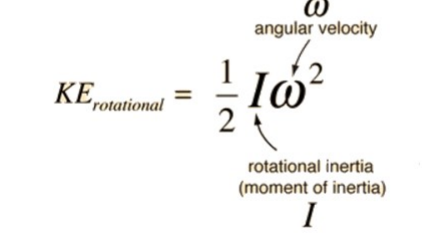
Description automatically generated

A diagram of a graph and a machine

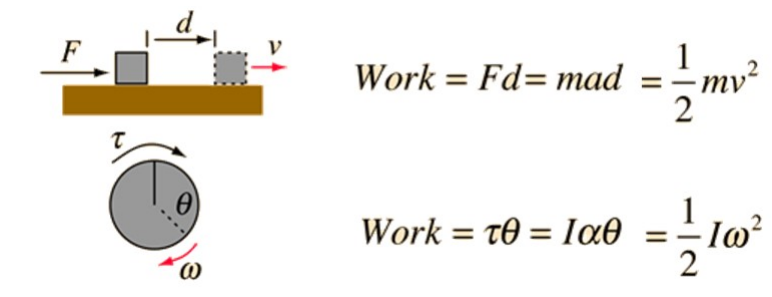
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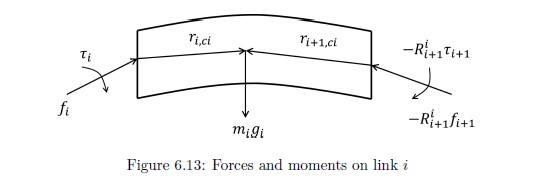
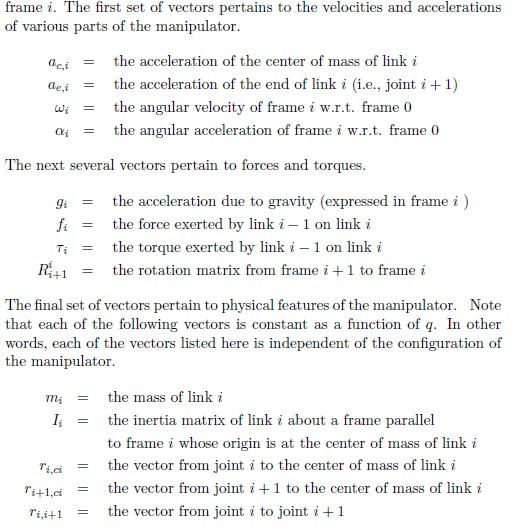
Description automatically generated

**Work:** Force applied to an object over a displacement

A close up of a text

Description automatically generated

Newton-Euler Formulation



Start with the base case for a single link or the base of the robot

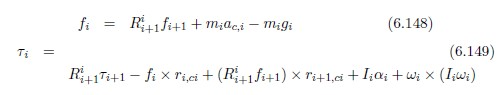
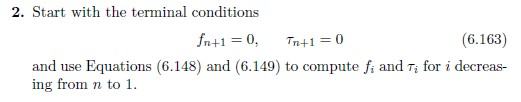
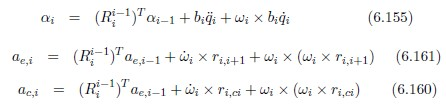
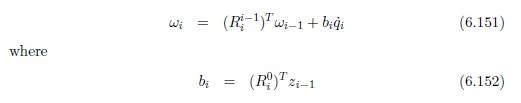
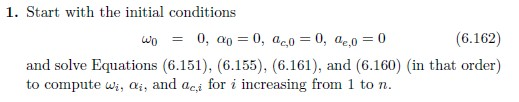
Newton's equation: calculate the net force and torque acting on the link

Euler's equation: computer the linear and angular acceleration of the link

Use the computed acceleration to update the linear and angular velocity and the position for the link

A diagram of a graphing of a device

Description automatically generated with medium confidenceA piece of paper with writing on it

Description automatically generatedRepeat the process for each link in the robot. Propagate the information from the base to the end effectorInverse Euler's equation: compute the joint torques required to produce the desired linear and angular acceleration for the current link

A notebook with writing on it

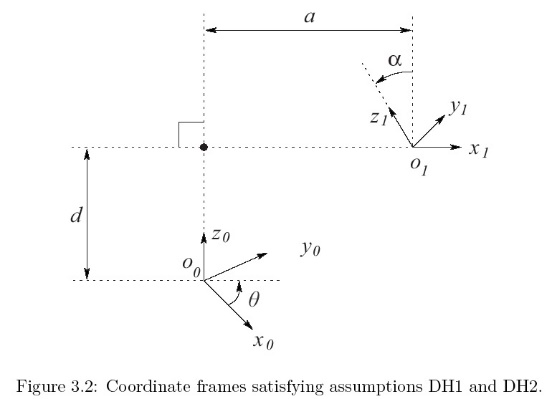
Description automatically generatedInverse newton's equation: calculate the joint torques required to counteract the net force and torque acting on the link

Move up the robot's kinematic chain, calculating the joint torques for each link from the end effector down to the base

A diagram of mathematical equations

Description automatically generated

Just PD controller can converge on steady state error and the integral portion helps fix that



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A black and white image of numbers and letters

Description automatically generatedA black text on a white background

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