Industrial Plants

(S.S.D. ING-IND/13)

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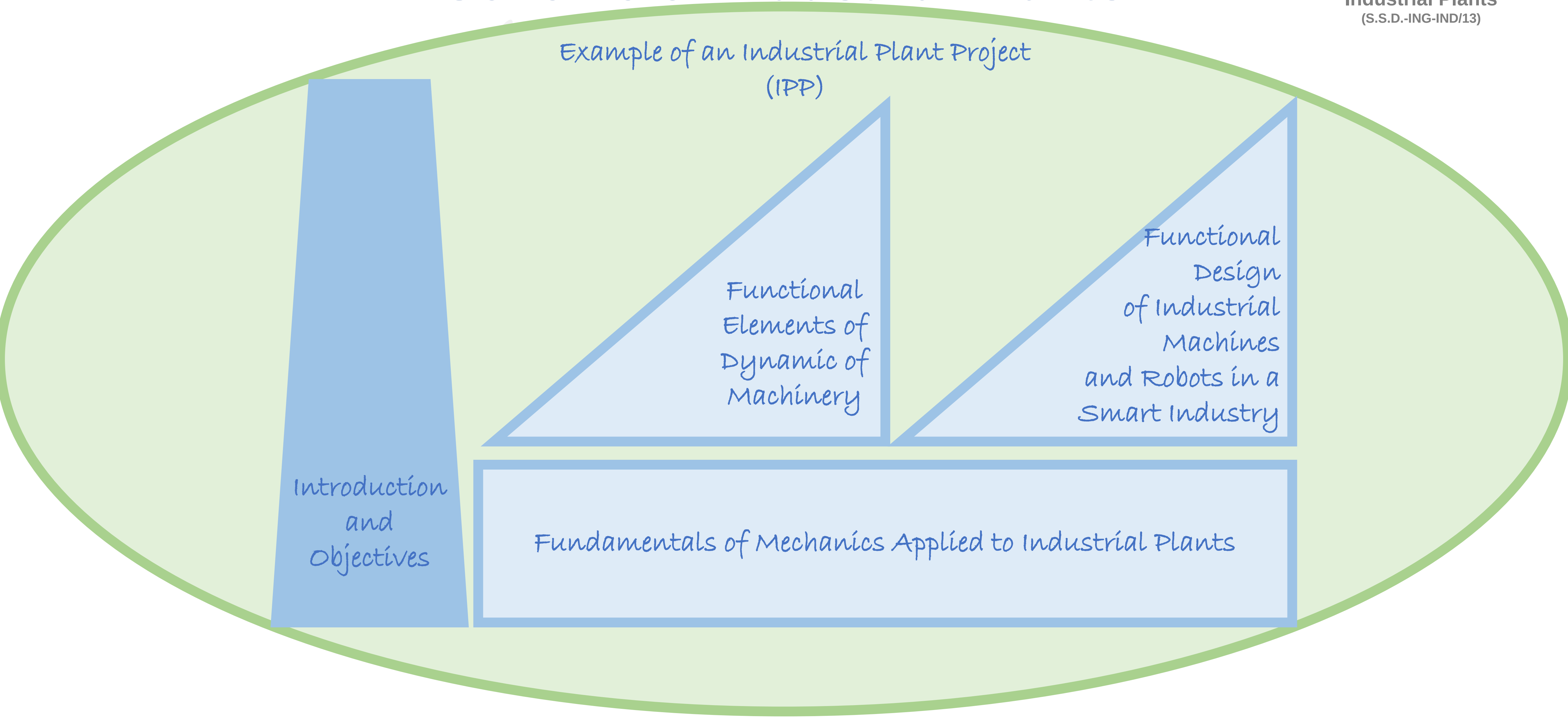
Program

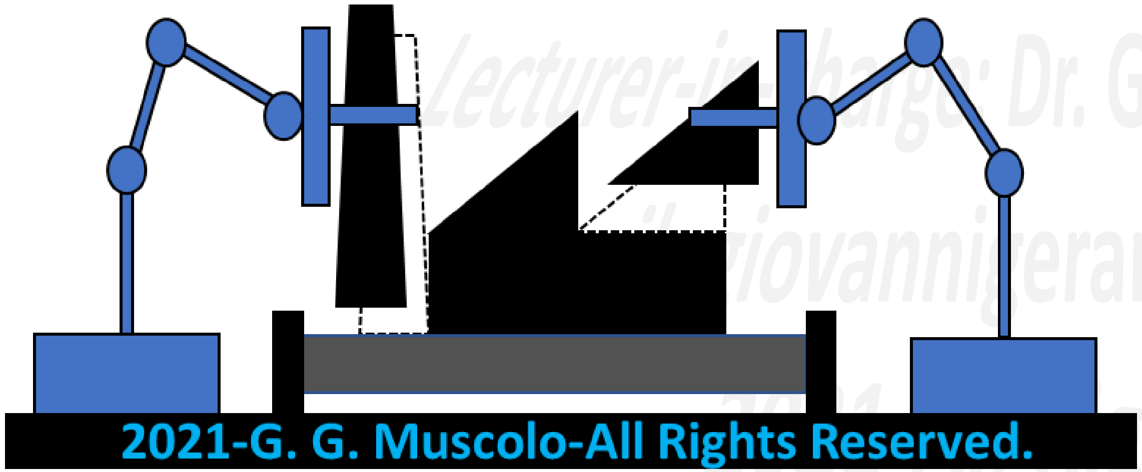
1. **Introduction and Objectives**
2. **Fundamentals of Mechanics Applied to Industrial Plants**
3. Functional Design of Industrial Machines and Robots in a Smart Industry
4. Functional Elements of Dynamic of Machinery
5. Example of an Industrial Plant Project (IPP)

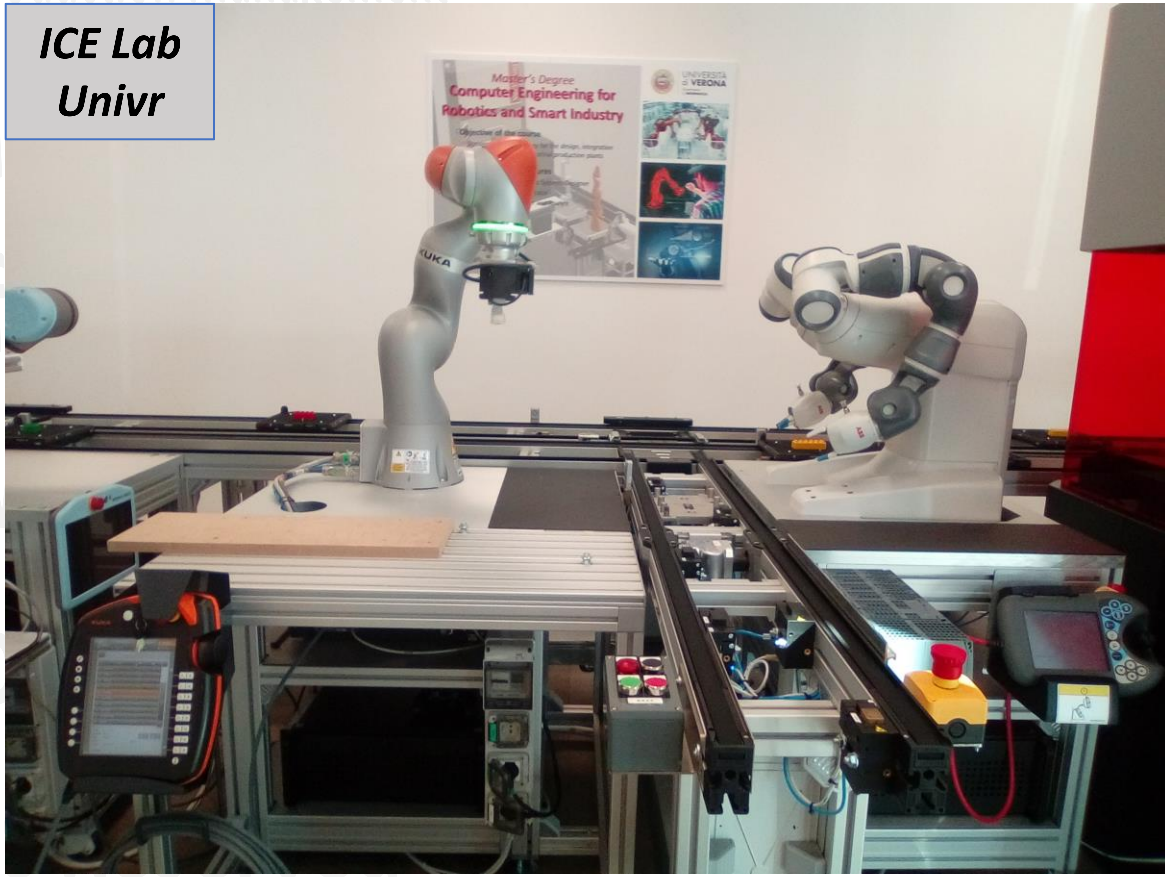
Scheme of Industrial Plants



<u>EXAMPLE (dynamics)</u>:

Balancing





Courtesy of the ICE Lab, University of Verona (Univr), Verona, Italy (https://www.icelab.di.univr.it/)

EXAMPLE (dynamics):

Balancing

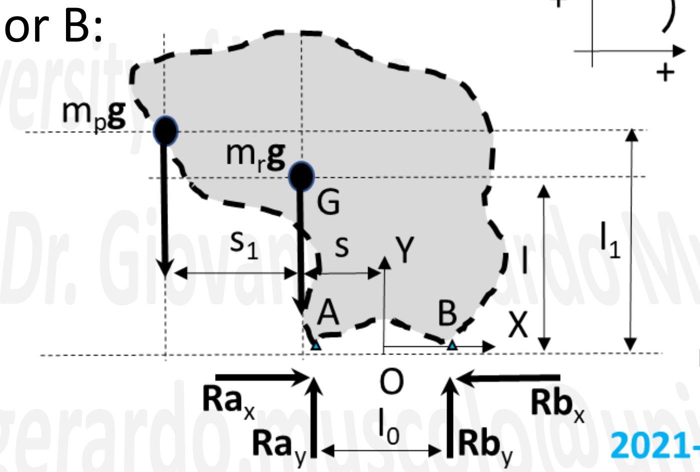
In order to semplify the equations we can calculate the torque respect to the point A or B:

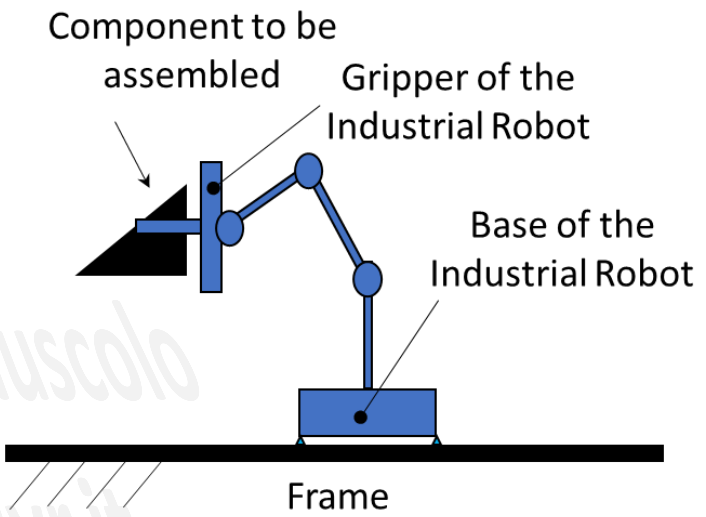
$$\sum M_O = 0 = -Ra_y \frac{l_0}{2} + s m_r g + (s + s_1) m_p g + Rb_y \frac{l_0}{2};$$

$$\sum M_A = 0 = (s - \frac{l_0}{2}) m_r g + \left(s - \frac{l_0}{2} + s_1\right) m_p g + Rb_y l_0;$$

$$\sum M_B = 0 = -Ra_y l_0 + (s + \frac{l_0}{2}) m_r g + \left(s + \frac{l_0}{2} + s_1\right) m_p g;$$

FREE-BODY DIAGRAM





EXAMPLE (dynamics):

Balancing

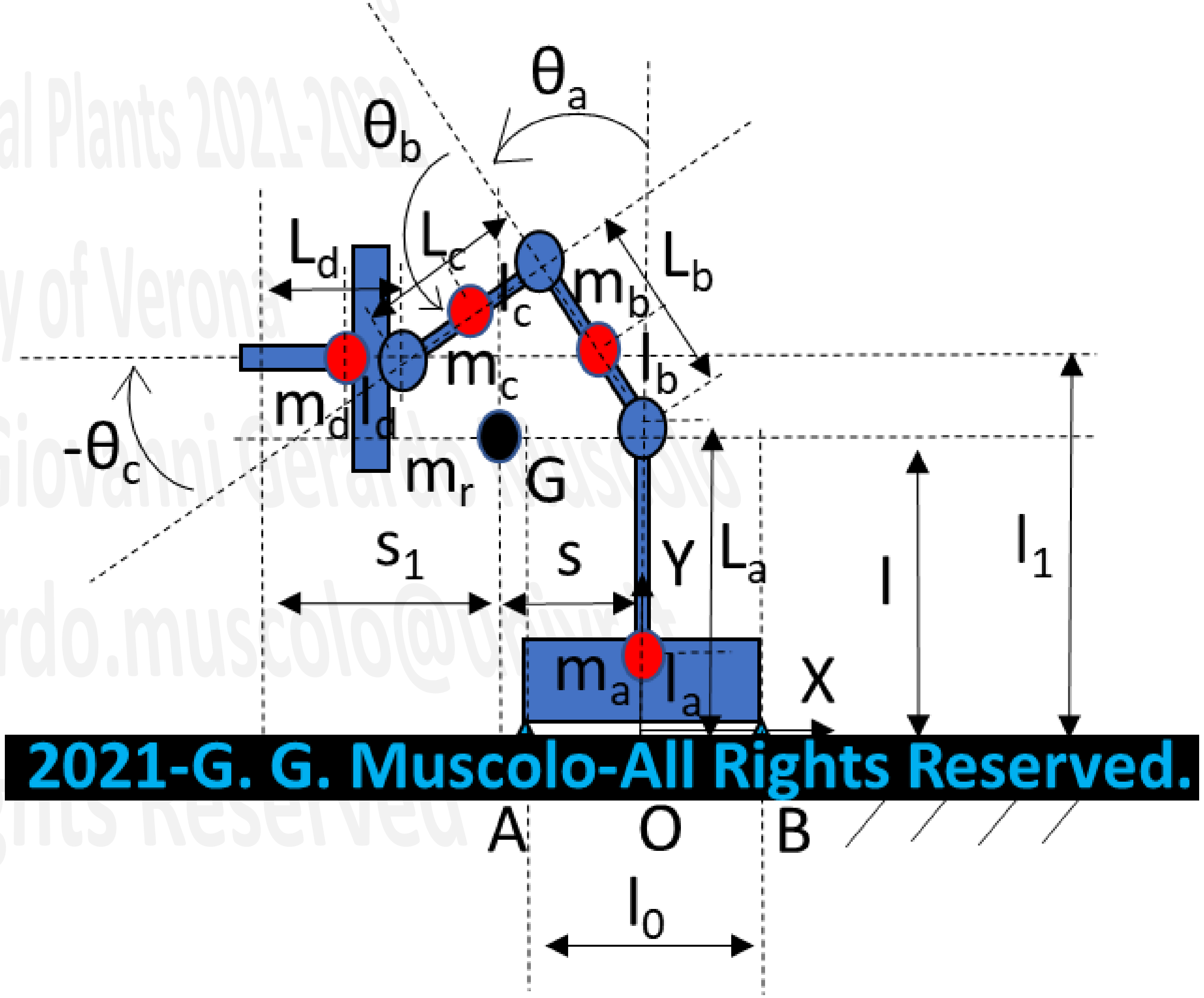
Position of the Center of Mass G (X_G, Y_G, Z_G)

$X_G = -s;$

$Y_G = l;$

$Z_G = 0;$ Planar condition

$m_r = m_a + m_b + m_c + m_d;$



EXAMPLE (dynamics):

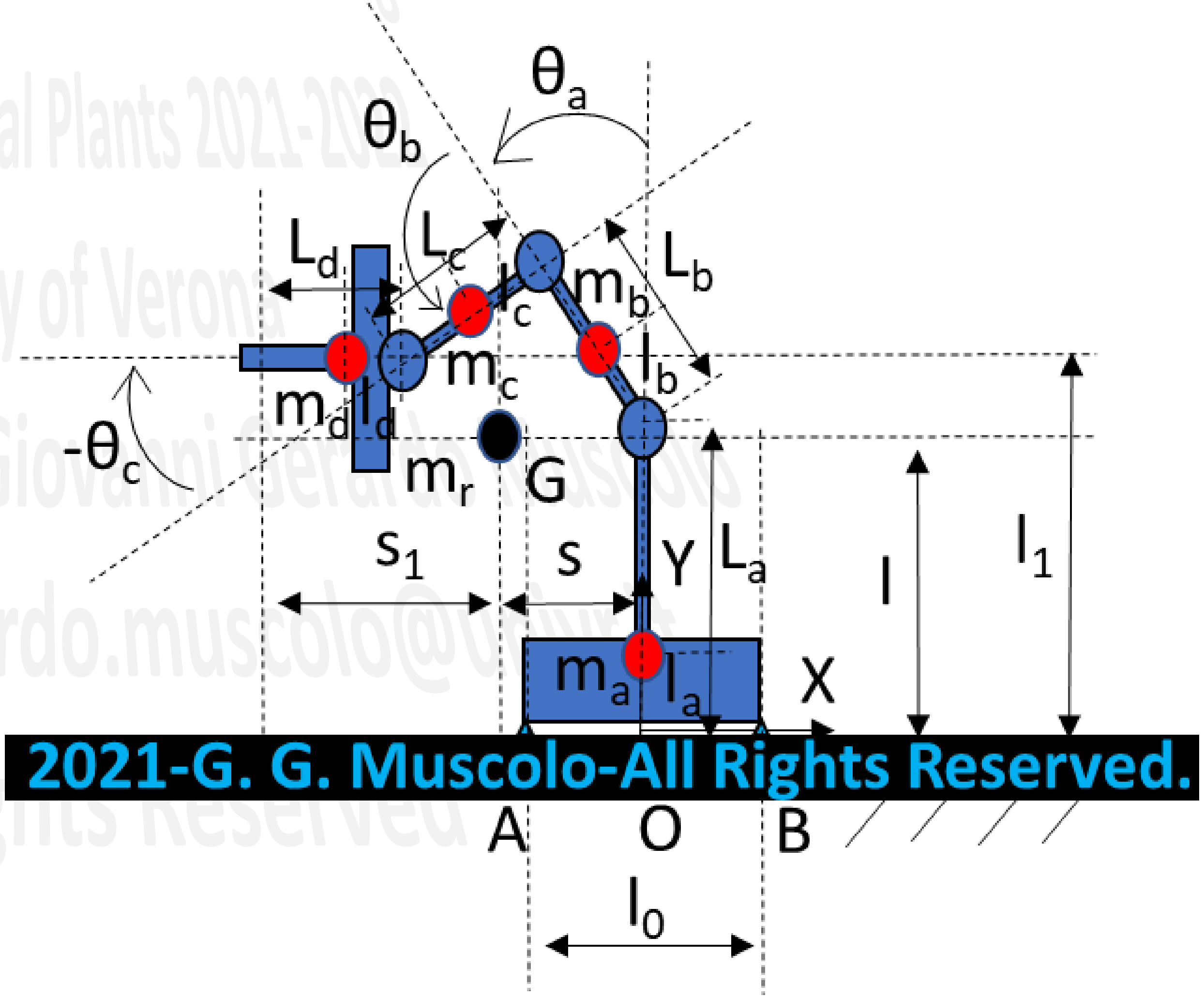
Balancing

General formulation of the Center of Mass G (X_G, Y_G, Z_G)

$$m_{ToT} X_G = \sum m_i x_i;$$

$$m_{ToT} Y_G = \sum m_i y_i;$$

$$m_{ToT} Z_G = \sum m_i z_i;$$



EXAMPLE (dynamics):

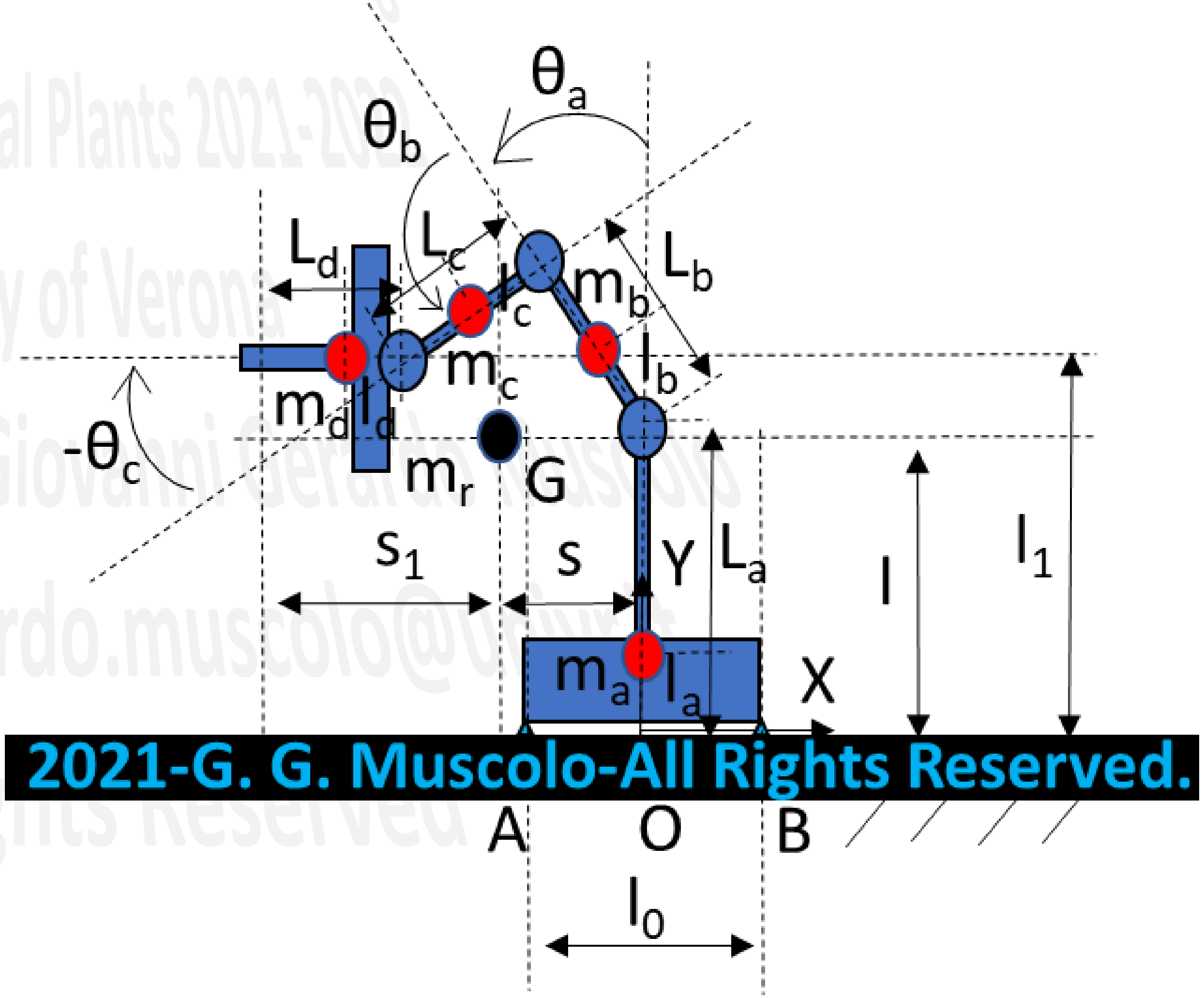
Balancing

General formulation of the Center of Mass G (X_G, Y_G, Z_G)

$$X_G = \frac{\sum m_i x_i}{m_{ToT}};$$

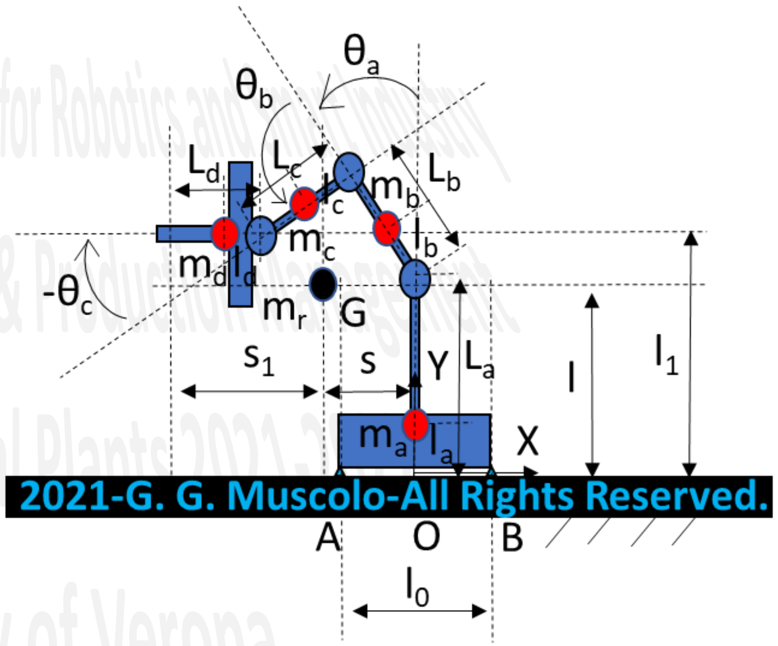
$$Y_G = \frac{\sum m_i y_i}{m_{ToT}};$$

$$Z_G = \frac{\sum m_i z_i}{m_{ToT}};$$



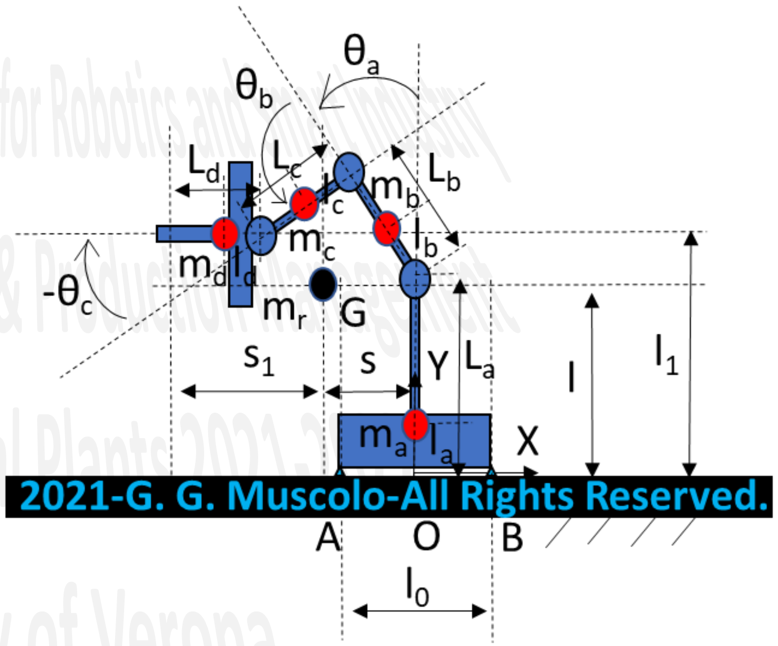
EXAMPLE (dynamics):

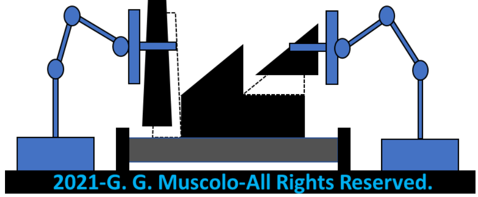
Balancing



Position of the Center of Mass G (X_G, Y_G, Z_G)

$$s = \frac{m_b l_b \sin(\theta_a)+m_c[l_c \cos(\theta_a+\theta_b-\pi/2)+L_b \sin(\theta_a)]+m_d[l_d+L_c \cos(\theta_a+\theta_b-\pi/2)+L_b \sin(\theta_a)]}{m_r};$$





<u>EXAMPLE (dynamics)</u>:

Balancing

Position of the Center of Mass G (X_G, Y_G, Z_G)

$$l = \frac{m_a l_a + m_b[L_a + l_b\cos(\theta_a)] + m_c[-l_c\sin(\theta_a+\theta_b-\pi/2) + L_a + L_b\cos(\theta_a)] + m_d[-L_c\sin(\theta_a+\theta_b-\pi/2) + L_a + L_b\cos(\theta_a)]}{m_r};$$

In order to increase the self balancing of the robot:

1) We could reduce «l» as soon as possible;
2) We could reduce «s» as soon as possible;
3) We could increase «l_0» as soon as possible;

EXAMPLE (dynamics):

Balancing

Position of the Center of Mass G (X_G, Y_G, Z_G)

In order to increase the self balancing of the robot:

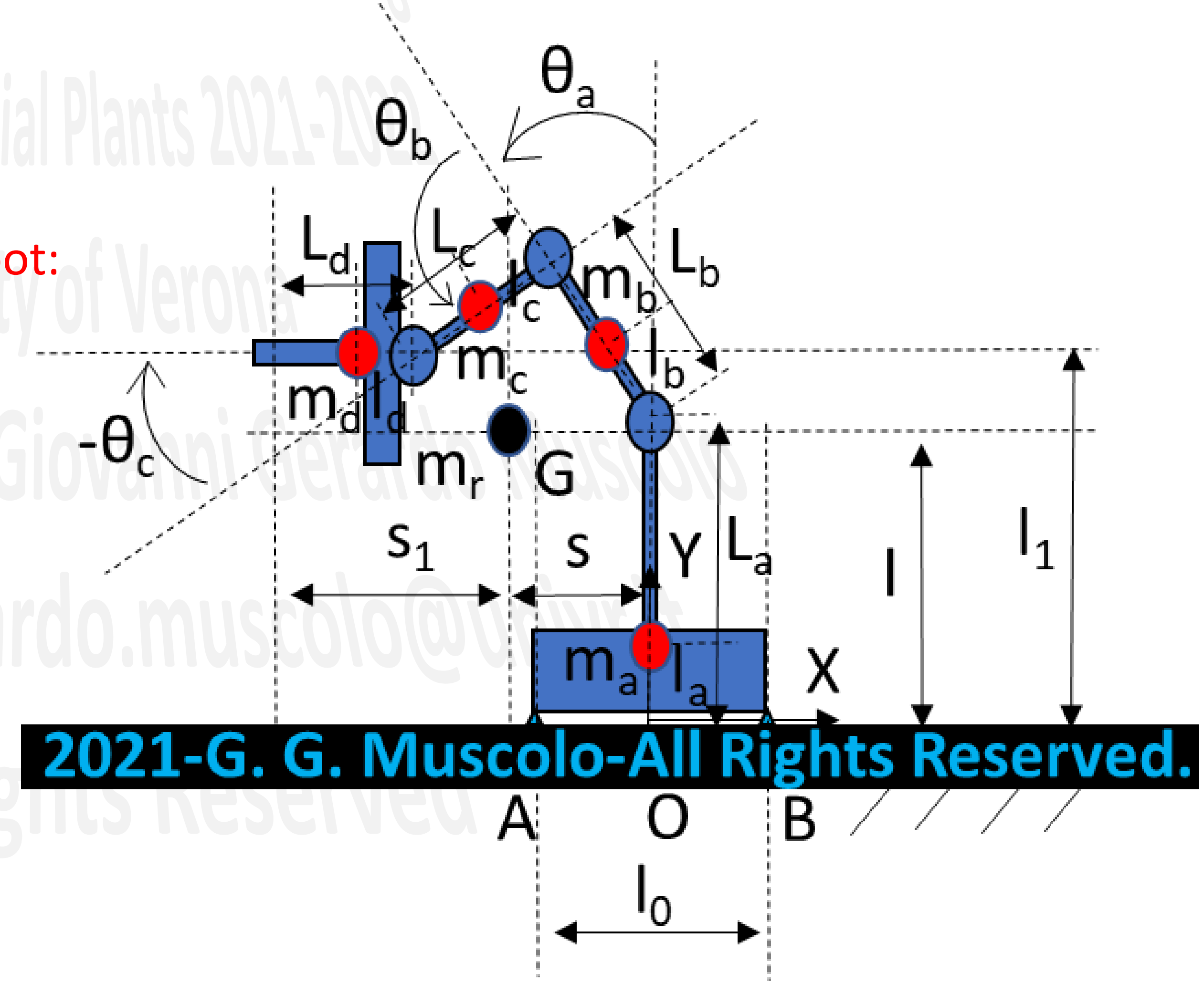
1) We could reduce «l» as soon as possible;
2) We could reduce «s» as soon as possible;
3) We could increase «l_0» as soon as possible;

i) reducing the values of m_b, m_c, m_d;

ii) increasing the value of m_a;

iii) increasing the length of l_0.

Why?



EXAMPLE (dynamics):

Balancing

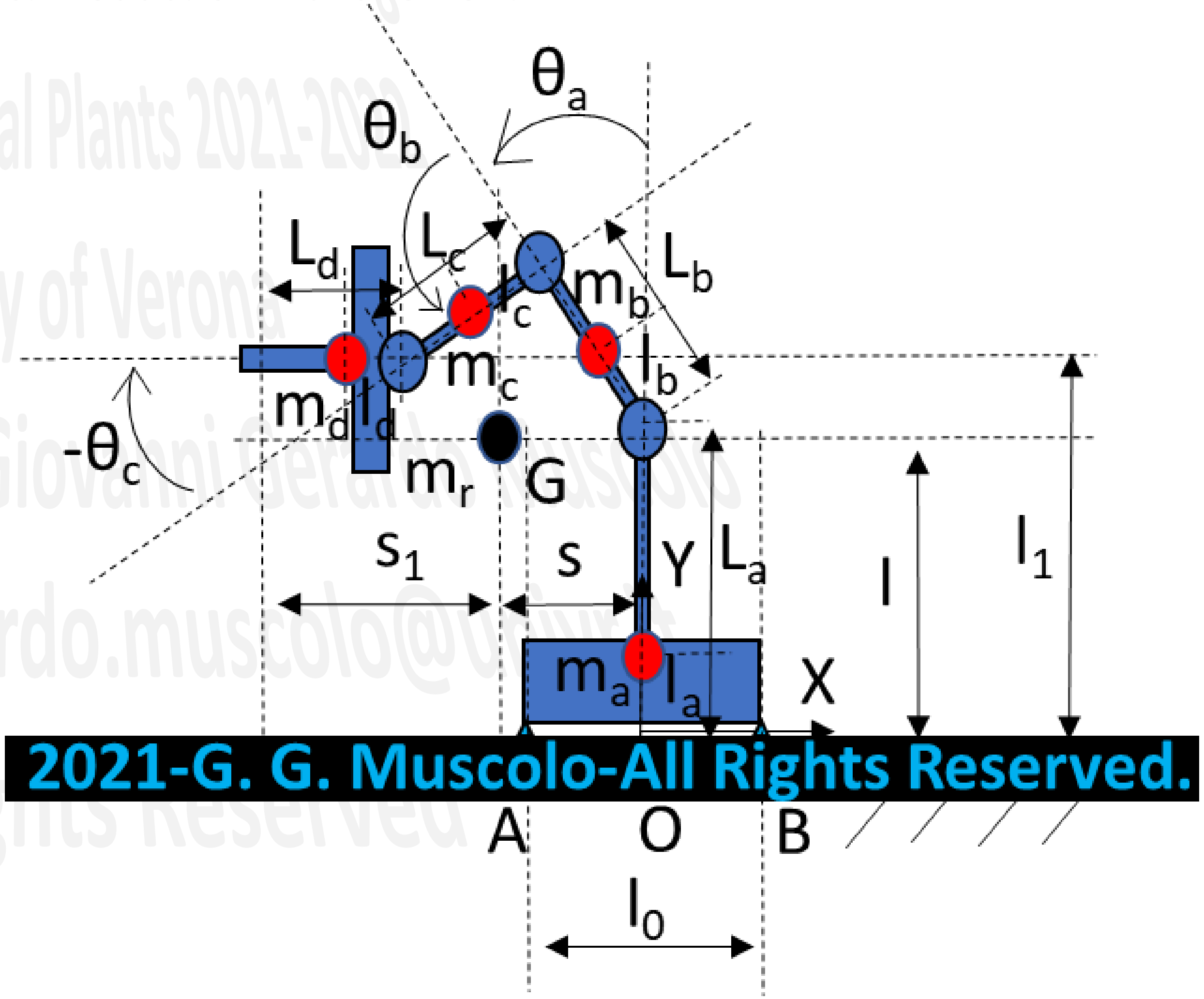
Position of the Center of Mass G (X_G, Y_G, Z_G)

Why?

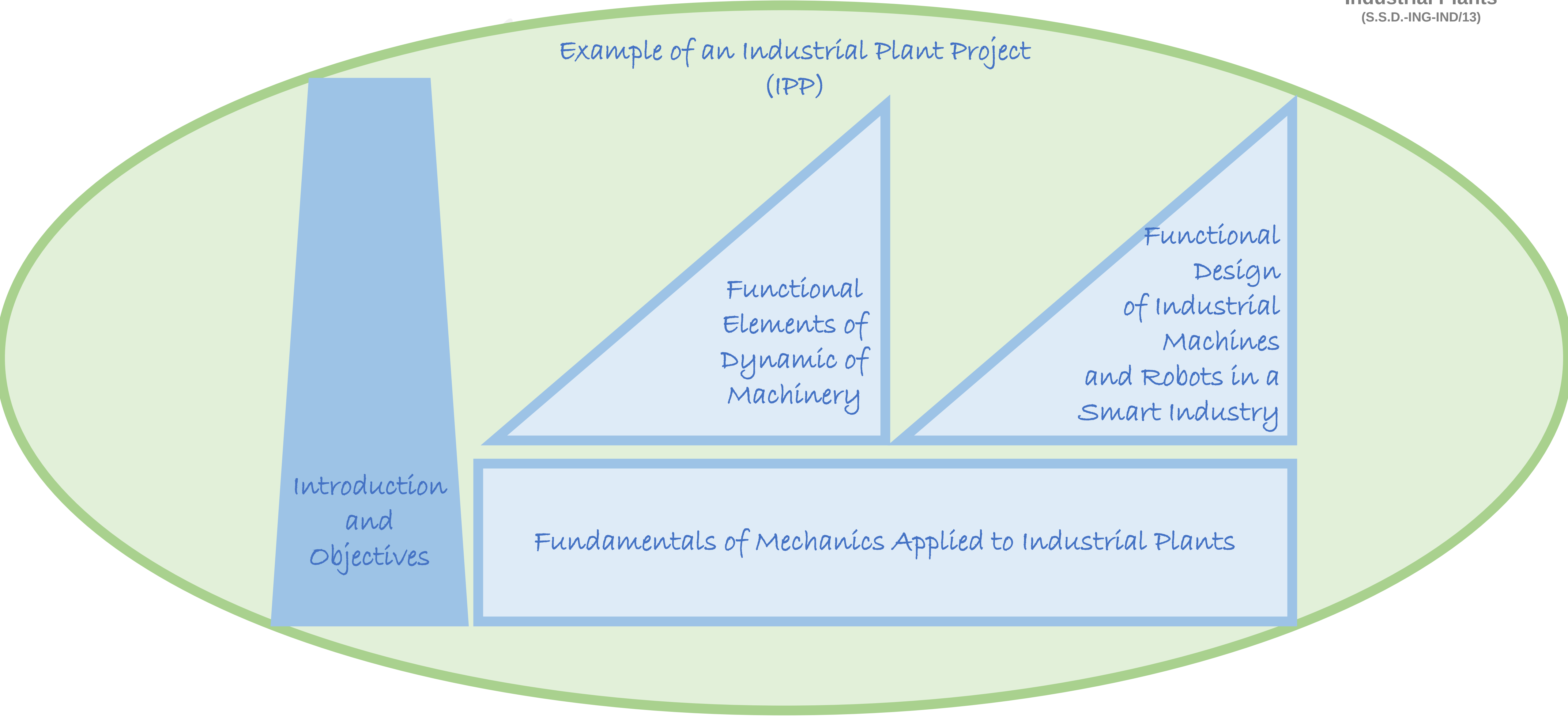
Because:

-) if the Center of Mass (G) is near the ground, falls are reduced;

-) if l_0 is high, the external planar torque for unbalancing must be higher.



Scheme of Industrial Plants



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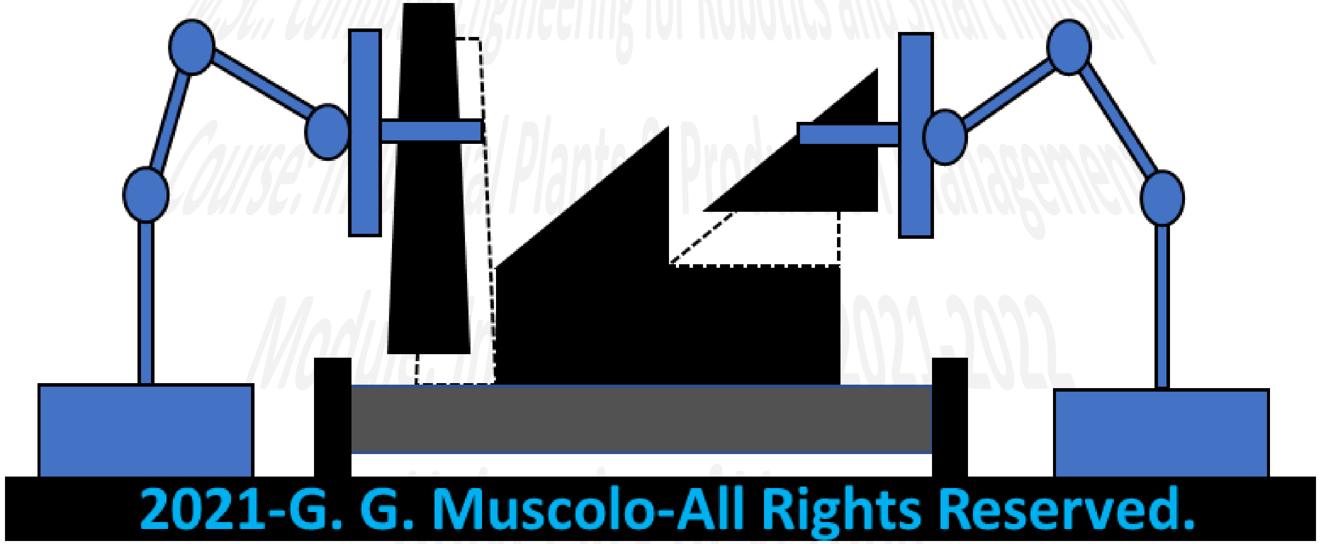

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