The pendulum/cart system is used to model the motion of an overhead crane. If the cart is given a specified acceleration profile of

\[
b(t) = \frac{3597e^x(1-e^y)}{(1+e^y)^3} + \frac{3597e^y(1-e^x)}{(1+e^x)^3} \text{ cm/s}^2
\]

where

\[
x = -43.5668t + 9.38
\]

\[
y = -43.5668t + 31.1633
\]

and \(0 < t < 0.9\),

Determine the best location of the moveable mass \(L_{wcg}\) such that the pendulum angular velocity is zero at \(t = 0.9\) seconds. Note that there will be an unknown force acting in the direction of the cart motion so that the cart experiences the specified acceleration.

pendulum mass \(m_p = 68.5\) g
moveable mass \(m_{add} = 88.0\) g
Pendulum length \(L_p = 43.2\) cm
sensor diameter \(d_s = 2.5\) cm
moveable weight diameter \(d_w = 5.0\) cm
pivot to moveable weight cg \(L_{wcg}\)
pivot to pendulum cg \(L_{pcg}\)

Notes:
- Draw the system in a displaced orientation to obtain the governing differential equation. (This is the most important part of the analysis part of this lab).
- Write your resulting non-linear differential equation as:

\[
[something] \ddot{\theta} + [something else] \sin(\theta) = [something different] b(t) \cos(\theta)
\]

When implementing this equation in Maple it should look something like this:

\[
diff_eq:=(IG_p+IG_w+mp*LG_p^2+mw*Lw^2)*\text{diff}(\theta(t),t^2)+(mp*LG_p+mw*Lw)*g*\sin(\theta(t))= ... \)

(right hand side missing on purpose – we don’t want to give you the whole answer!)

- Maple can numerically solve the non-linear differential equation of motion using:
  \(>\text{soln := dsolve(}\{\text{diff}_\text{eq}, \theta(0)=0, D(\theta)(0)=0\}, \theta(t),\text{numeric}\);\)

To plot your solution use
  \(>\text{odeplot(soln, [t,D(\theta)(t)], 0..2, numpoints=300);}\)

Be sure to include \(>\text{with(plots):}\) at the beginning of your Maple Worksheet. Once your Maple worksheet is working correctly you can vary \(L_w\) to find the location where the angular velocity is zero at the end of the acceleration.