LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Quad Pendulum Parameter Descriptions and Naming Convention

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Table of Contents

1 Introduction

1.1 Purpose and Scope

Describes the parameter names used in the Mathematica and Matlab quad pendulum dynamics models.

1.2 References

LIGO-T1400446: aLIGO SUS Pendulum Dynamics Modeling

LIGO-T020205: Models of the Advanced LIGO Suspensions in Mathematica™

LIGO-T080188: Models of the Advanced LIGO Suspensions in MATLAB

1.3 Version history

7/7/2014: -v1. Initial version based on triple document, T040072-v1.

2 Parameters

The following parameters are the minimum set necessary to define a case of the Mathematica QuadLite2Lateral model used for the aLIGO QUAD main and reaction chains, or the equivalent Matlab model. As near as practical, all of the parameters have the same names in both models. The parameters for blade and wire stiffness are defined per side in the Matlab but per blade in the Mathematica, and to prevent (total) confusion have been given different names. Except for the d's, n's and s's, parameters are numbered 0 (or n = new, relative to triple), 1, 2, 3 by blade/wire/mass from the top down. The Mathematica model has a large number of additional parameters for the damping of the elastic elements which are beyond the scope of this document. The Matlab model also handles certain additional Mathematica models that were generated for R&D purposes, e.g, , QuadLite2LateralWC etc, but the extra parameters which trigger this are beyond the scope of this document.

2.1 Parameters common to Mathematica and Matlab

Parameter	Unit	Description
g	m/s^2	local gravity
mn	kg	mass of top mass
Inx, Iny, Inz	kg.m^2	diagonal components of top mass MOI
Inxy, Inyz, Inzx	kg.m^2	off-diagonal components of top mass MOI
m1	kg	mass of upper intermediate mass (UIM)
I1x, I1y, I1z	kg.m^2	diagonal components of upper intermediate mass MOI
I1xy, I1yz, I1zx	kg.m^2	off-diagonal components of upper intermediate mass MOI
m2	kg	mass of penultimate mass (PUM)

I2x, I2y, I2z	kg.m^2	diagonal components of penultimate mass MOI
I2xy, I2yz, I2zx	kg.m^2	off-diagonal components of penultimate mass MOI
m3	kg	mass of lower mass
I3x, I3y, I3z	kg.m^2	diagonal components of lower mass MOI
I3xy, I3yz, I3zx	kg.m^2	off-diagonal components of lower mass MOI
dtop, dm, dn, d0, d1, d2, d3, d4	m	vertical offsets of wire attachments from COM (positive outward, towards wire) - see diagrams
nn0, nn1, n0, n1, n2, n3, n4, n5	m	half lateral (y-direction) wire attachment point separations, - see diagrams
su, si, sl	m	half front-back (x-direction) wire attachment point separations of intermediate and lower wires, common to top and bottom - see diagrams
ln, l1, l2, l3	m	stretched lengths of wires
Yn, Y1, Y2, Y3	Pa	Young's moduli of wires
rn, r1, r2, r3	m	radii of wires

2.2 Parameters unique to Matlab

Parameter	Unit	Description
kcn, kc1, kc2	N/m	blade vertical stiffnesses ***per side***, equivalent to kbuz, kbiz and kblz in Mathematica
kxn, kx1, kx2	N/m	blade lateral stiffnesses ***per side***, equivalent to kbux, kbix and kblx in Mathematica
stage2	-	switch governing the interpretion of the d's: state2=1 => d's are physical, apply flexure correction; stage2=0 => d's are effective, flexure correction already included, don't reapply.
bd	N/(m/s), N.m/(rad/s)	a small amount of damping which is added to all DOFs to avoid unrealistically peaky TFs; defaults to 0.001.

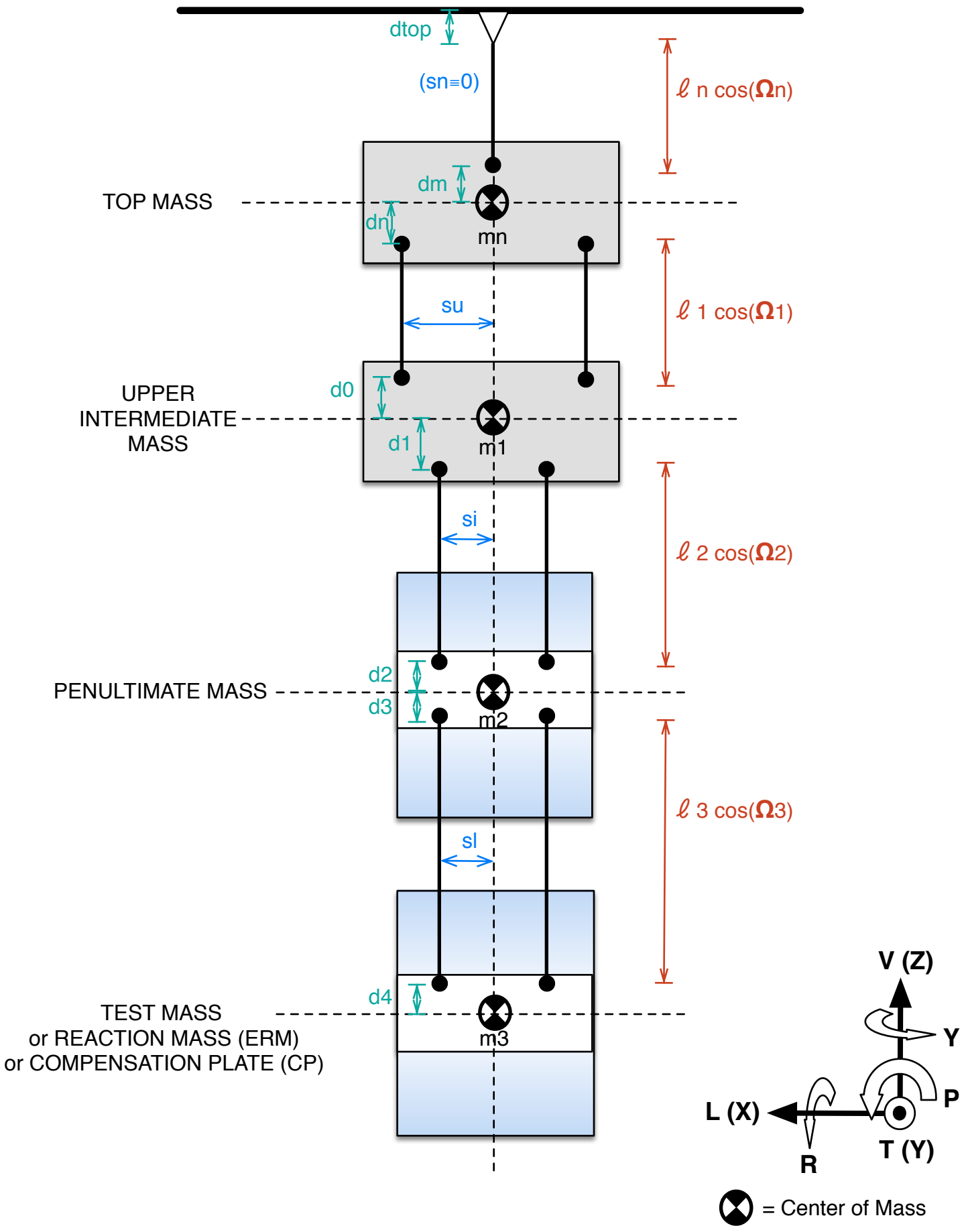
2.3 Parameters unique to Mathematica

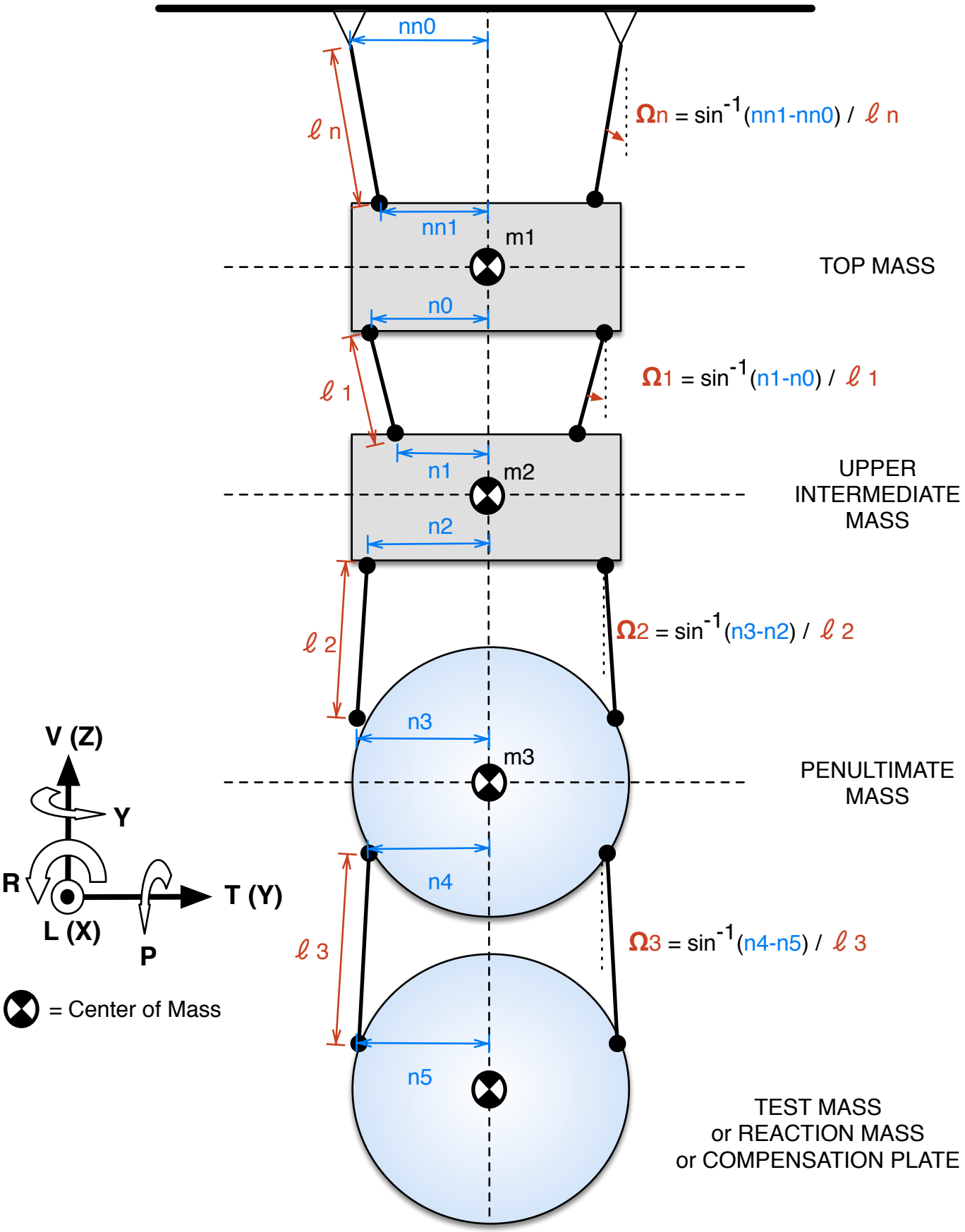
Parameter	Unit	Description
kbuz, kbiz, kblz	N/m	blade vertical stiffnesses ***per blade***, equivalent to kcn, kc1 and kc2 in Matlab
kbux, kbix, kblx	N/m	blade lateral stiffnesses ***per blade***, equivalent to kxn, kx1 and kx2 in Matlab
kwn, kw1, kw2, kw3	N/m	wire vertical stiffnesses, per wire; case definer needs to

		calculate these manually whereas they are calculated automatically in the Matlab

3 Diagrams

In the final PDF of this document, OmniGraffle diagrams of the dimensional parameters will be appended.


dtop
(sn≡0)
ℓ n cos(Ωn)
TOP MASS
dm
dn
mn
su
ℓ 1 cos(Ω1)
UPPER
INTERMEDIATE
MASS
d0
d1
m1
si
ℓ 2 cos(Ω2)
PENULTIMATE MASS
d2
d3
m2
ℓ 3 cos(Ω3)
sl
d4
TEST MASS
or REACTION MASS (ERM)
or COMPENSATION PLATE (CP)
m3
V (Z)
Y
P
L (X)
T (Y)
R
= Center of Mass


nn0
ℓ n
Ωn = sin-1(nn1-nn0) / ℓ n
nn1
m1
TOP MASS
n0
ℓ 1
Ω1 = sin-1(n1-n0) / ℓ 1
n1
m2
UPPER
INTERMEDIATE
MASS
n2
ℓ 2
Ω2 = sin-1(n3-n2) / ℓ 2
n3
m3
PENULTIMATE
MASS
n4
ℓ 3
Ω3 = sin-1(n4-n5) / ℓ 3
n5
TEST MASS
or REACTION MASS
or COMPENSATION PLATE
V (Z)
Y
R
T (Y)
L (X)
P
= Center of Mass