In[2123]:=
```
ClearAll["Global`*"]

(* http://mini.pw.edu.pl/~porter/cc/psw/psw_cw2.pdf *)
(* System: Two bars and a cone *)

(* ------------- Global Variables -------------- *)
$Density := 1;

(* ------------- Functions -------------- *)

$I[$Integral_, x_, y_, z_] := {
   {$Integral[y^2 + z^2],
    -$Integral[x*y],
    -$Integral[x*z]},
   {-$Integral[x* y],
    $Integral[x^2 + z^2],
    -$Integral[y*z]},
   {-$Integral[x*z ],
    -$Integral[y*z],
    $Integral[y^2+x^2]}};

$IPointFun[x_, y_, z_, m_] :=
  m* {
    {y^2+z^2, -x*y, -x*z},
    {-x*y, x^2 + z^2, -y*z},
    {-x*z, -y*z, x^2+y^2}};

$PlotInertiaTensor[I_, a_] := Show[ContourPlot3D[
   {{ix, iy, iz}.I.{ix, iy, iz} == 1}, {ix, -a, a}, {iy, -a, a}, {iz, -a, a}]]

$Angle = -30°;
```

$RotationY = $\begin{pmatrix} Cos[\$Angle] & 0 & Sin[\$Angle] \\ 0 & 1 & 0 \\ -Sin[\$Angle] & 0 & Cos[\$Angle] \end{pmatrix}$;

```
(* --------------------------------------- *)
(* Cone *)
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$ConeR = $\sqrt{3}$;

$ConeSlant = 2 $\sqrt{3}$;

$ConeH = $\sqrt{\$ConeSlant\verb|^|2 - \$ConeR\verb|^|2}$;

```
$xCone[r_, θ_, z_] := r*Cos[θ];
$yCone[r_, θ_, z_] := r*Sin[θ];
$zCone[r_, θ_, z_] := z;
```

```
$ConeParam[r_, θ_, z_] := {$xCone[r, θ, z], $yCone[r, θ, z], $zCone[r, θ, z]};

$JacobianCone[r_, θ_, z_] :=
  (D[$xCone[r, θ, z], r]  D[$xCone[r, θ, z], θ]  D[$xCone[r, θ, z], z]
   D[$yCone[r, θ, z], r]  D[$yCone[r, θ, z], θ]  D[$yCone[r, θ, z], z]
   D[$zCone[r, θ, z], r]  D[$zCone[r, θ, z], θ]  D[$zCone[r, θ, z], z]);
$JacobianDetCone[r_, θ_, z_] := Abs[Det[$JacobianCone[r, θ, z]]];

$ConeIntegralVariables[R_, H_, a_] :=
  $Density * ∫_0^R ∫_0^(2 π) ∫_(1+H/R r)^(1+H) $JacobianDetCone[r, θ, z] * a ⅆz ⅆθ ⅆr;
$ConeIntegral[a_] := $ConeIntegralVariables[$ConeR, $ConeH, a];


$ConeMass = $ConeIntegral[1];
$ConeCenterOfMass := {
    $ConeIntegral[$xCone[r, θ, z]],
    $ConeIntegral[$yCone[r, θ, z]],
    $ConeIntegral[$zCone[r, θ, z]]} / $ConeMass;
$ICone = $I[$ConeIntegral,
   $xCone[r, θ, z],
   $yCone[r, θ, z],
   $zCone[r, θ, z]];

(* Bar Y *)
$BarYIntegral[a_] := $Density ∫_-1^1 a ⅆy;
$BarYMass = $BarYIntegral[1];
$BarYCenterOfMass :=
  {$BarYIntegral[0], $BarYIntegral[y], $BarYIntegral[0]} / $BarYMass;
$IBarY = $I[$BarYIntegral, 0, y, 0];

(* Bar Z *)
$BarZIntegral[a_] := $Density ∫_0^1 a ⅆz;
$BarZMass = $BarZIntegral[1];
$BarZCenterOfMass :=
  {$BarZIntegral[0], $BarZIntegral[0], $BarZIntegral[z]} / $BarZMass;
$IBarZ = $I[$BarZIntegral, 0, 0, z];

(* All *)
$MassAll = $ConeMass + $BarYMass + $BarZMass;
$CenterOfMassAll = ($ConeMass * $ConeCenterOfMass +
     $BarYMass * $BarYCenterOfMass + $BarZMass * $BarZCenterOfMass) / $MassAll;
```

```
$IAll = $ICone + $IBarY  + $IBarZ;
$IAllPoint = $IPointFun[
   $CenterOfMassAll[[1]],
   $CenterOfMassAll[[2]],
   $CenterOfMassAll[[3]],
   $MassAll];
$IAllCenter = $IAll - $IAllPoint;
$IAllCenterRotated = $RotationY.$IAllCenter.Transpose[$RotationY];
$CenterOfMassAllA =  $RotationY.$CenterOfMassAll;

(* Around A *)
$A = {0, 1, 0};
$IAPoint = $IPointFun[
   $CenterOfMassAllA[[1]] - $A[[1]],
   $CenterOfMassAllA[[2]] - $A[[2]],
   $CenterOfMassAllA[[3]] - $A[[3]],
   $MassAll];
$IA = $IAPoint + $IAllCenterRotated;

$f = {0, 0, -$MassAll * g};
$N = Cross[$CenterOfMassAllA, $f];
W = {Wx, Wy, Wz};
Wt = {Wtx, Wty, Wtz};

Print["Center of Mass around A"]
MatrixForm[N[$CenterOfMassAllA]]
Print["Gravity"]
MatrixForm[N[$f]]
Print["Torque (body)"]
MatrixForm[N[$N]]

Print["Euler Equation"]
StringForm["````=`` + Cross[````,``]",
 MatrixForm[N[$IA]], MatrixForm[Wt], MatrixForm[N[$N]],
 MatrixForm[N[$IA]], MatrixForm[W], MatrixForm[W]]
StringForm["Qt=Q `` / 2", W]
```

Center of Mass around A

Out[2167]//MatrixForm=

$$\begin{pmatrix} -1.25276 \\ 0. \\ 2.16984 \end{pmatrix}$$

Gravity

Out[2169]//MatrixForm=

$$\begin{pmatrix} 0. \\ 0. \\ -12.4248\,g \end{pmatrix}$$

Torque (body)

Out[2171]//MatrixForm=

$$\begin{pmatrix} 0. \\ -15.5653\,g \\ 0. \end{pmatrix}$$

Euler Equation

Out[2173]=

$$\begin{pmatrix} 95.6904 & -15.5653 & 42.7913 \\ -15.5653 & 107.305 & 26.9598 \\ 42.7913 & 26.9598 & 46.2793 \end{pmatrix} \begin{pmatrix} Wtx \\ Wty \\ Wtz \end{pmatrix} = \begin{pmatrix} 0. \\ -15.5653\,g \\ 0. \end{pmatrix} + \mathrm{Cross}\left[\begin{pmatrix} 95.6904 & -15.5653 & 42.7913 \\ -15.5653 & 107.305 & 26.9598 \\ 42.7913 & 26.9598 & 46.2793 \end{pmatrix} \begin{pmatrix} Wx \\ Wy \\ Wz \end{pmatrix}, \begin{pmatrix} Wx \\ Wy \\ Wz \end{pmatrix}\right]$$

Out[2174]= Qt=Q {Wx, Wy, Wz} / 2

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