

QEA Project 1: Boat Design

Quantitative Engineering Analysis Project 1

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Boat Design - Sparistopher

In this section, we define (in this order)

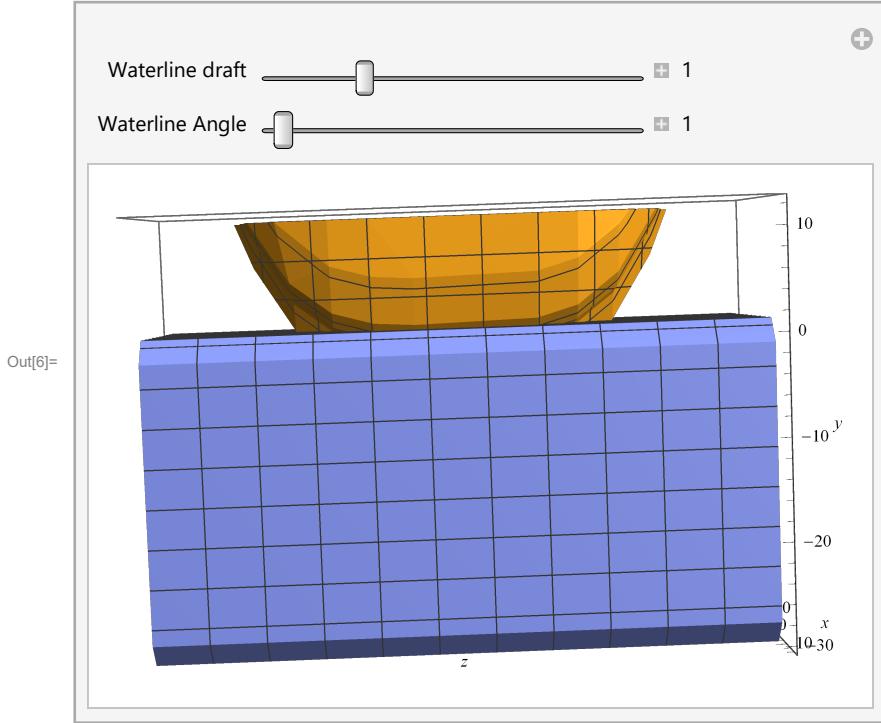
- (i) The curves which comprise the shape of the hull of our boat,
- (ii) The waterline with respect to the boat,
- (iii) The region of the boat that is under the water, and
- (iv) A function for analysis of the hull design - the variations of the waterline in terms of the draft and the waterline angle.

```
In[1]:= boat1 = ImplicitRegion[
  -14 <= x <= 14 && -(x/3 + 1.5)^3 + Abs[(z/11)^4] <= y <= 12 && -28 <= z <= 28, {x, y, z}];
boat2 = ImplicitRegion[-14 <= x <= 14 && (x/3 - 1.5)^3 + Abs[(z/11)^4] <= y <= 12 &&
  -28 <= z <= 28, {x, y, z}];
boat = RegionIntersection[boat1, boat2];
water = ImplicitRegion[
  y < Tan[\[Theta] Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
Manipulate[RegionPlot3D[{under /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, water /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, boat},
  AspectRatio \[Rule] Automatic, PlotTheme \[Rule] "Scientific", AxesLabel \[Rule] {x, y, z}],
  {{dd, 1, "Waterline draft"}, -5, 20, Appearance \[Rule] "Labeled"}, {{\[Theta]\[Theta], 1, "Waterline Angle"}, 0, 180, Appearance \[Rule] "Labeled"}]

Out[3]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
  0.037037 (-4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12, {x, y, z}]

Out[4]= ImplicitRegion[y < d + x Tan[\[Theta]] && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]

Out[5]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
  0.037037 (-4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 &&
  y < d + x Tan[\[Theta]] && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]
```

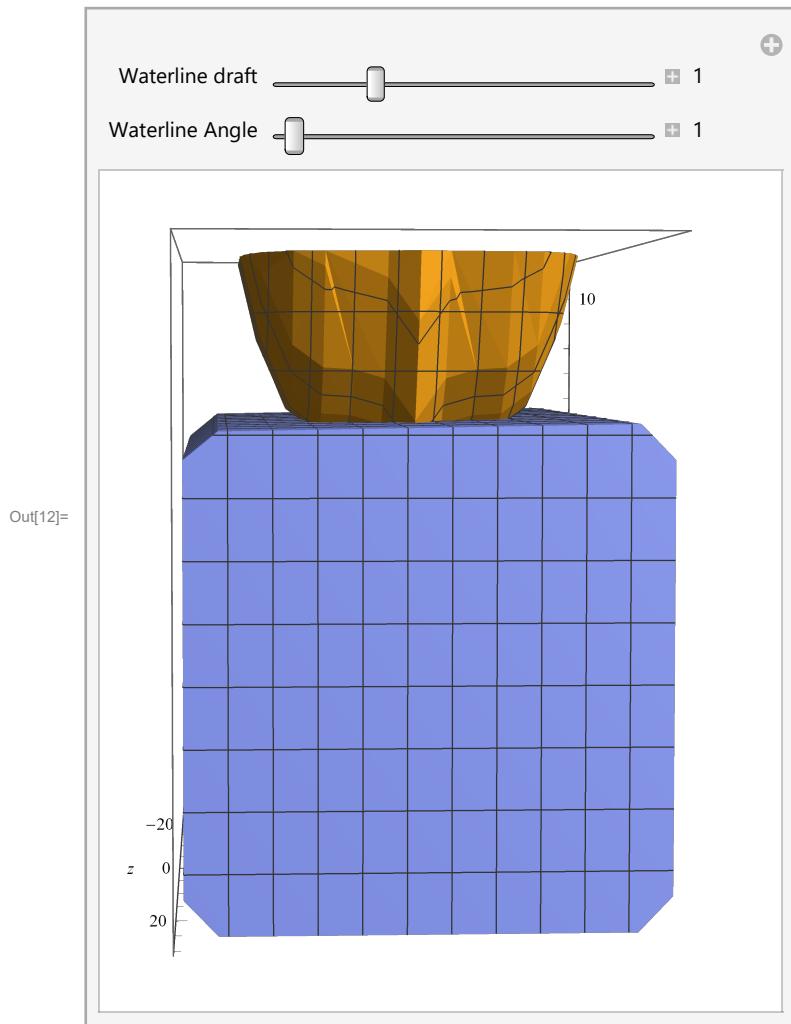


```
In[7]:= boat1 = ImplicitRegion[
  -14 <= x <= 14 && -(x/3 + 1.5)^3 + Abs[((z)/11)^4] <= y <= 12 && -28 <= z <= 28, {x, y, z}];
boat2 = ImplicitRegion[-14 <= x <= 14 && (x/3 - 1.5)^3 + Abs[((z)/11)^4] <= y <= 12 &&
  -28 <= z <= 28, {x, y, z}];
boat = RegionIntersection[boat1, boat2];
water = ImplicitRegion[
  y < Tan[\[Theta] Degree]*x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]
under = RegionIntersection[boat, water];
Manipulate[RegionPlot3D[{under /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, water /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, boat},
  AspectRatio \[Rule] Automatic, PlotTheme \[Rule] "Scientific", AxesLabel \[Rule] {x, y, z}],
  {{dd, 1, "Waterline draft"}, -5, 20, Appearance \[Rule] "Labeled"}, {{\[Theta]\[Theta], 1, "Waterline Angle"}, 0, 180, Appearance \[Rule] "Labeled"}]

Out[9]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
  0.037037 (-4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12, {x, y, z}]

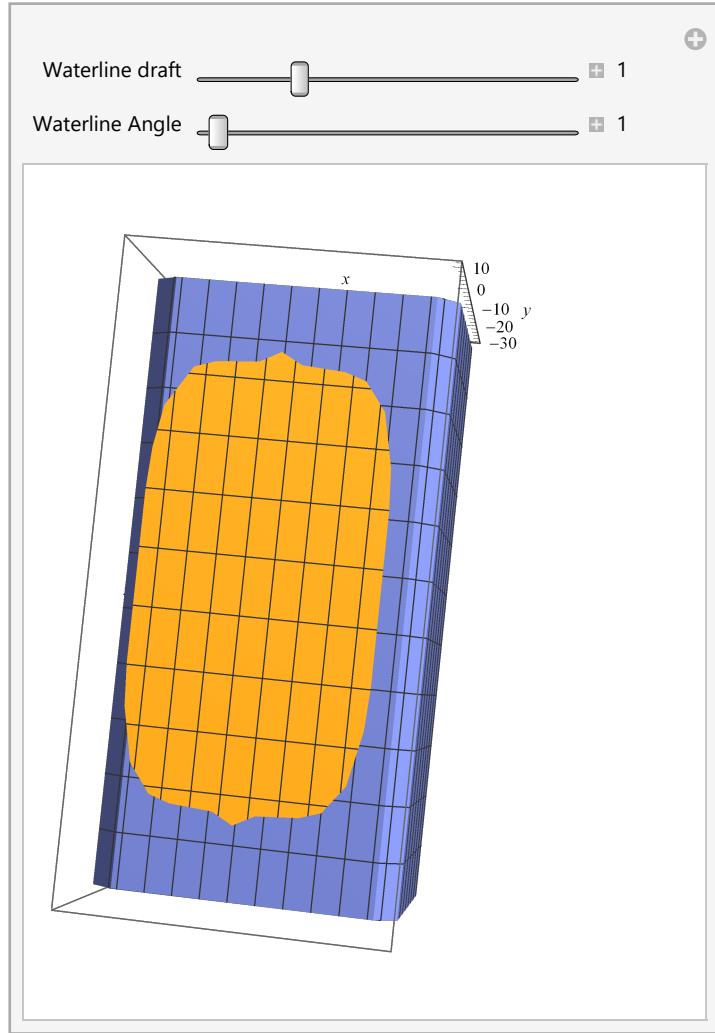
Out[10]= ImplicitRegion[y < d + x Tan[\[Theta] Degree] && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]

Out[11]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
  0.037037 (-4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 &&
  y < d + x Tan[\[Theta] Degree] && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]
```

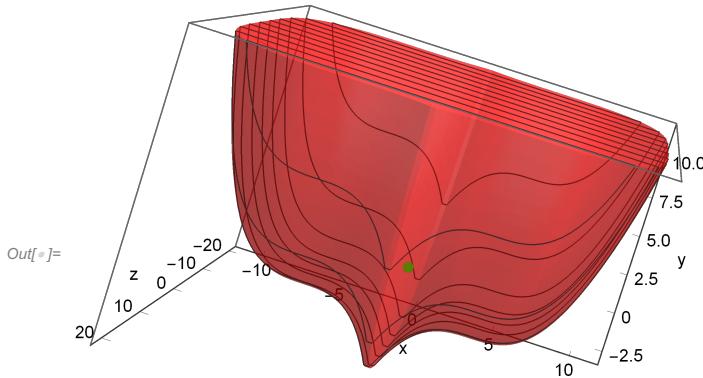


```
In[13]:= boat1 = ImplicitRegion[
  -14 <= x <= 14 && - (x / 3 + 1.5)^3 + Abs[(((z) / 11)^4)] <= y <= 12 && -28 <= z <= 28, {x, y, z}];
boat2 = ImplicitRegion[-14 <= x <= 14 && (x / 3 - 1.5)^3 + Abs[((z) / 11)^4)] <= y <= 12 &&
  -28 <= z <= 28, {x, y, z}];
boat = RegionIntersection[boat1, boat2];
water = ImplicitRegion[
  y < Tan[\[Theta] Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
Manipulate[RegionPlot3D[{under /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, water /. {d \[Rule] dd, \[Theta] \[Rule] \[Theta]\[Theta]}, boat},
  AspectRatio \[Rule] Automatic, PlotTheme \[Rule] "Scientific", AxesLabel \[Rule] {x, y, z}],
  {{dd, 1, "Waterline draft"}, -5, 20, Appearance \[Rule] "Labeled"}, {{\[Theta]\[Theta], 1, "Waterline Angle"}, 0, 180, Appearance \[Rule] "Labeled"}]
Out[15]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
  0.037037 (-4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)^3 +  $\frac{z^4}{14641}$  <= y <= 12, {x, y, z}]
Out[16]= ImplicitRegion[y < d + x Tan[\[Degree] \[Theta]] && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}]
```

```
Out[17]= ImplicitRegion[-28 <= z <= 28 && -14 <= x <= 14 &&
0.037037 (-4.5 + x)3 +  $\frac{z^4}{14641}$  <= y <= 12 && -0.037037 (4.5 + x)3 +  $\frac{z^4}{14641}$  <= y <= 12 &&
y < d + x Tan [ ° θ ] && -15 < x < 15 && -30 < y < 100 && -30 < z <= 30, {x, y, z}]
```



```
In[1]:= (* Test Plotter *)
Show[
  RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, 
  PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]], 
  ListPointPlot3D[{ {0, 1.72755, 0}}, PlotStyle -> Directive[Green, Opacity[1]]]]
```



In this section, we plot the Center of Mass and Center of Buoyancy on a 3D plot of our boat for several heel angles:

0 Degree

Green Label - COM

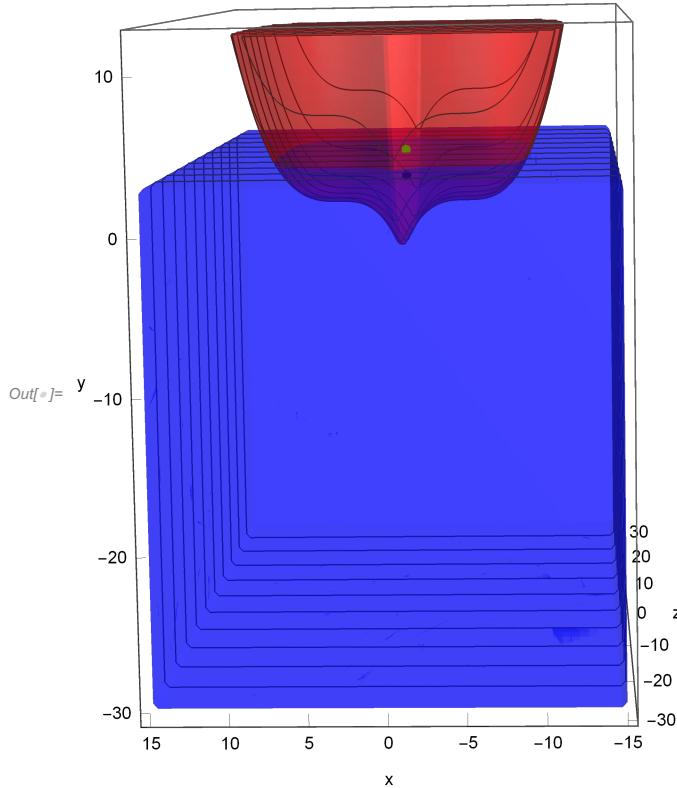
Black Label - COB

```
In[2]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y < Tan[0 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ → 0}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}]][[1]]];
cob = RegionCentroid[under /. {d → draft, θ → 0}]

Out[2]= 3.04709

Out[3]= {-5.97325 × 10-17, 1.41403, -2.55604 × 10-7}
```

```
In[6]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft, θ -> 0}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{com}, PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{cob}, PlotStyle -> Directive[Black, Opacity[1]]]]
```



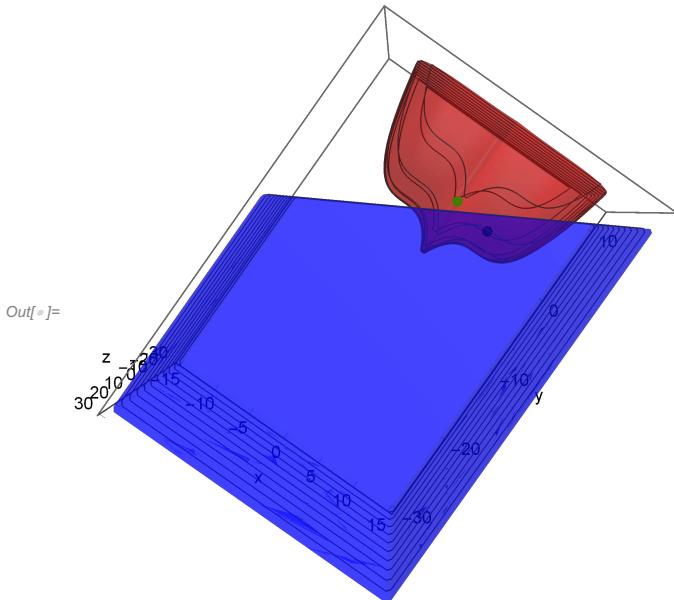
30 Degree

```
In[7]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y < Tan[30 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ -> 30}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}][[1]]];
cob = RegionCentroid[under /. {d -> draft, θ -> 30}]
```

Out[7]= 2.01655

```
Out[8]= {4.27488, 2.51152, -5.48583 × 10-17}
```

```
In[6]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft, θ -> 30}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{com}], PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{cob}], PlotStyle -> Directive[Black, Opacity[1]]]
```



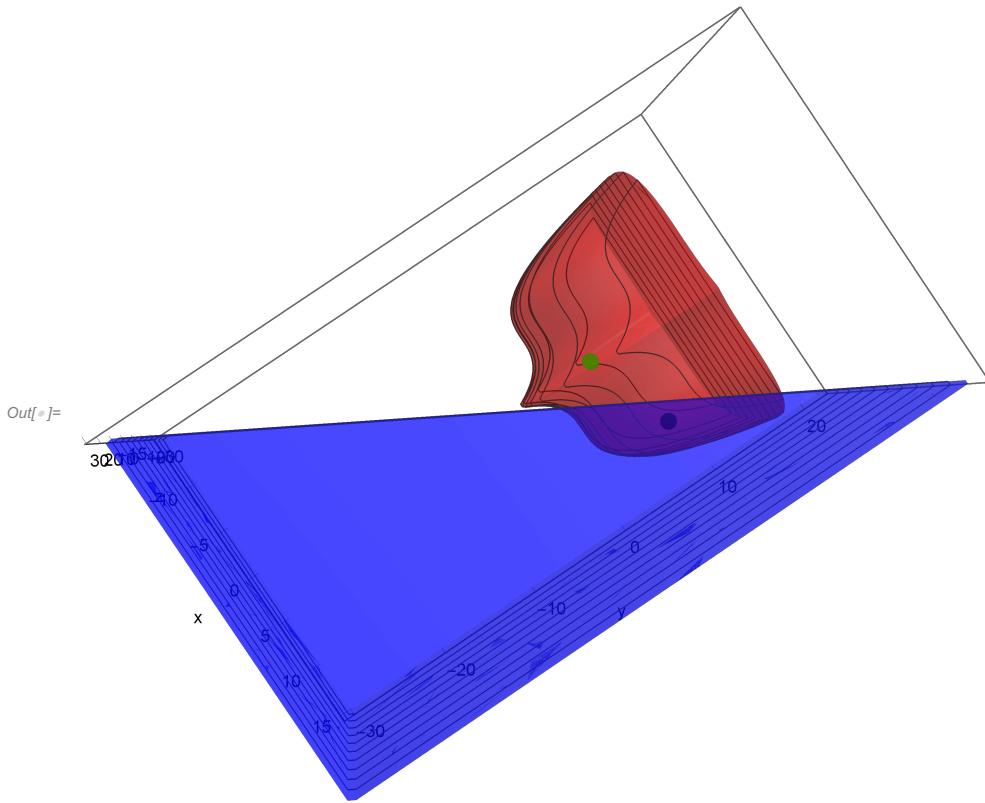
60 Degree

```
In[7]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y < Tan[60 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ -> 60}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}]][[1]]];
cob = RegionCentroid[under /. {d -> draft, θ -> 60}]

Out[7]= -3.91481

Out[8]= {7.46538, 5.78314, -4.25666 × 10-16}
```

```
In[6]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft, θ -> 60}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{com}], PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{cob}], PlotStyle -> Directive[Black, Opacity[1]]]]
```



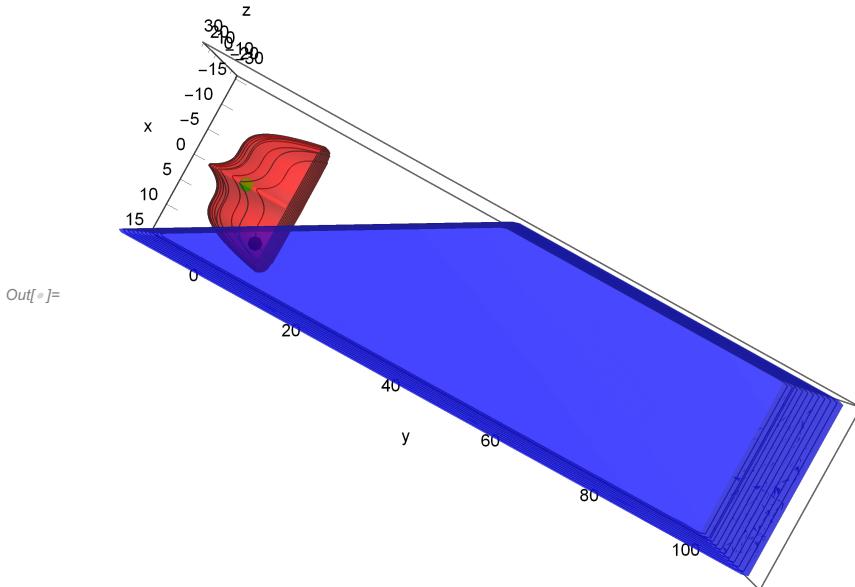
120 Degree

```
In[7]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y > Tan[120 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ -> 120}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}][[1]]];
cob = RegionCentroid[under /. {d -> draft, θ -> 120}]

Out[7]= 17.7406

Out[8]= {7.66226, 9.05742, -4.78493 × 10-17}
```

```
In[1]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft, θ -> 120}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{com}], PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{cob}], PlotStyle -> Directive[Black, Opacity[1]]]
```



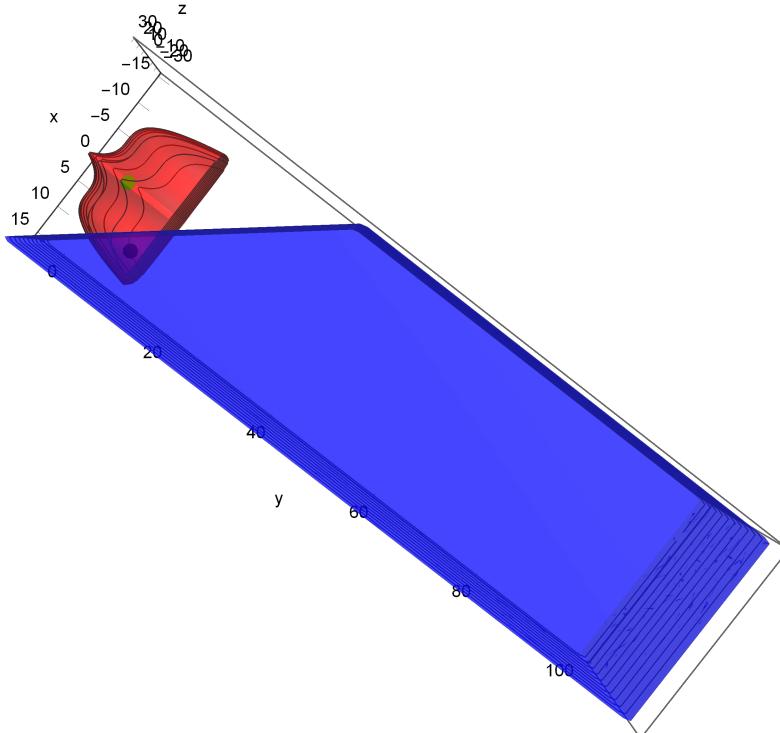
130 Degree

```
In[2]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y > Tan[130 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ -> 130}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}]][[1]]];
cob = RegionCentroid[under /. {d -> draft, θ -> 130}]
```

Out[2]= 14.7071

Out[3]= {7.41353, 9.41234, -1.13808 × 10⁻¹⁶}

```
In[6]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft, θ -> 130}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{com}], PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{cob}], PlotStyle -> Directive[Black, Opacity[1]]]
```



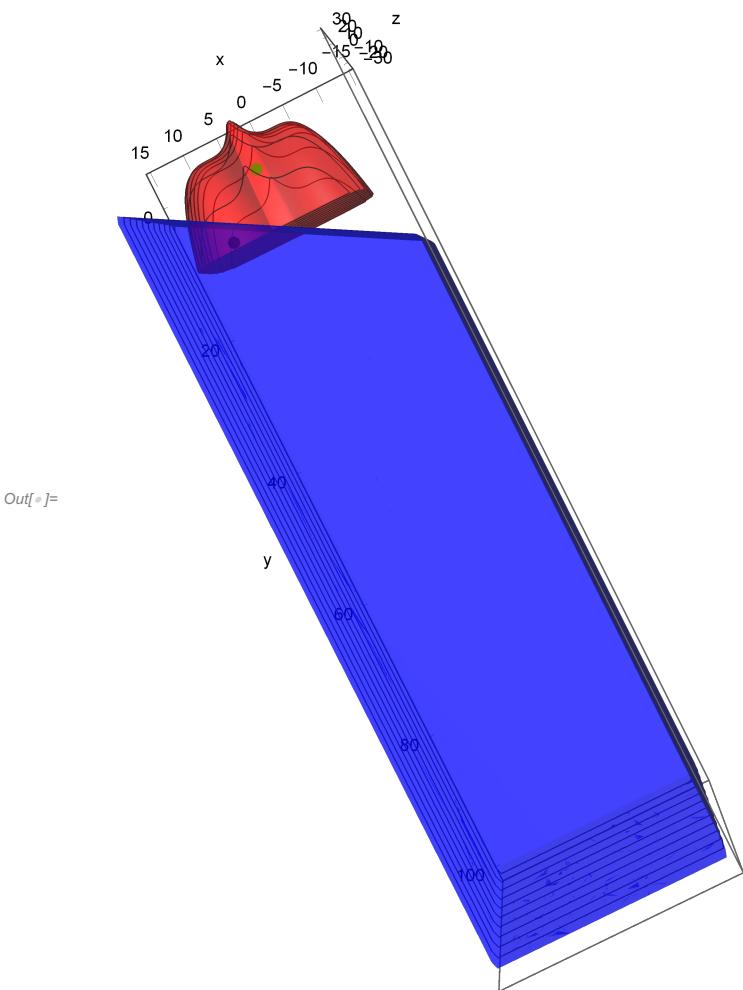
150 Degree

```
In[7]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y > Tan[150 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} ∈ under /. {θ -> 150}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}][[1]]];
cob = RegionCentroid[under /. {d -> draft, θ -> 150}]
```

Out[7]= 11.6427

Out[8]= {6.59459, 10.0814, -9.93713 × 10⁻¹⁷}

```
In[ $\circ$ ]:= Show[
RegionPlot3D[boat, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Red, Opacity[0.5]]],
RegionPlot3D[water /. {d -> draft,  $\theta$  -> 150}, PlotTheme -> "Web", AxesLabel -> {"x", "y", "z"}, PlotPoints -> 100, PlotStyle -> Directive[Blue, Opacity[0.5]]],
ListPointPlot3D[{{com}}, PlotStyle -> Directive[Green, Opacity[1]]],
ListPointPlot3D[{{cob}}, PlotStyle -> Directive[Black, Opacity[1]]]]
```



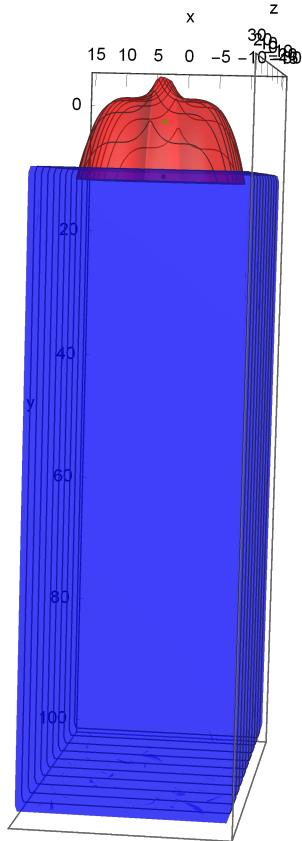
180 Degree

```
In[6]:= mass = 1315;
com = {0, 3.25, 0};
water = ImplicitRegion[
  y > Tan[180 Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
under = RegionIntersection[boat, water];
disp = Integrate[1, {x, y, z} \[Element] under /. {\[Theta] \[Rule] 180}];
draft = N[d /. FindRoot[disp == mass, {d, -20, 20}][[1]]];
cob = RegionCentroid[under /. {d \[Rule] draft, \[Theta] \[Rule] 180}]

Out[6]= 10.4711

Out[7]= {-1.56094 \times 10^{-17}, 11.243, 3.04664 \times 10^{-16}}
```

```
In[8]:= Show[
  RegionPlot3D[boat, PlotTheme \[Rule] "Web", AxesLabel \[Rule] {"x", "y", "z"},
   PlotPoints \[Rule] 100, PlotStyle \[Rule] Directive[Red, Opacity[0.5]]],
  RegionPlot3D[water /. {d \[Rule] draft, \[Theta] \[Rule] 180}, PlotTheme \[Rule] "Web", AxesLabel \[Rule] {"x", "y", "z"},
   PlotPoints \[Rule] 100, PlotStyle \[Rule] Directive[Blue, Opacity[0.5]]],
  ListPointPlot3D[{com}, PlotStyle \[Rule] Directive[Green, Opacity[1]]],
  ListPointPlot3D[{cob}, PlotStyle \[Rule] Directive[Black, Opacity[1]]]]
```



In this section, we define the variables that we obtained from the SolidWorks

Model of our boat:

- (i) Mass of the Boat
- (ii) COM of the Boat
- (iii) Mass of the Ballast
- (iv) The COM of the boat - ballast assembly (Calculated in Mathematica)

```
In[1]:= newcomcode[comballast_] := Module[{ },
  massboat = 315;
  comboat = {0, 11.21, 0};
  massballast = 1000;
  newcom = ((massboat * comboat) + (massballast * comballast)) / (massboat + massballast);
  newcom
]

In[2]:= newcomcode[{0, 0.7485, 0}]
Out[2]= {0, 3.25449, 0}
```

In this section, we define the functions that we use to obtain the righting moment that is acting on the boat. Waterline Angle < 90 Degrees

```
In[1]:= Submergedless90[θθ_] := Module[{ },
  mass = 1315;
  com = {0, 3.25, 0};
  water = ImplicitRegion[
    y < Tan[θθ Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
  under = RegionIntersection[boat, water];
  disp = Integrate[1, {x, y, z} ∈ under /. {θ → θθ}];
  draft = N[d /. FindRoot[disp == mass, {d, -20, 20}]][[1]]];
  cob = RegionCentroid[under /. {d → draft, θ → θθ}];
  buoyancy = mass * 980 * {-Sin[θθ Degree], Cos[θθ Degree], 0};
  torque = Cross[cob - com, buoyancy][[3]];
  torque
]
```

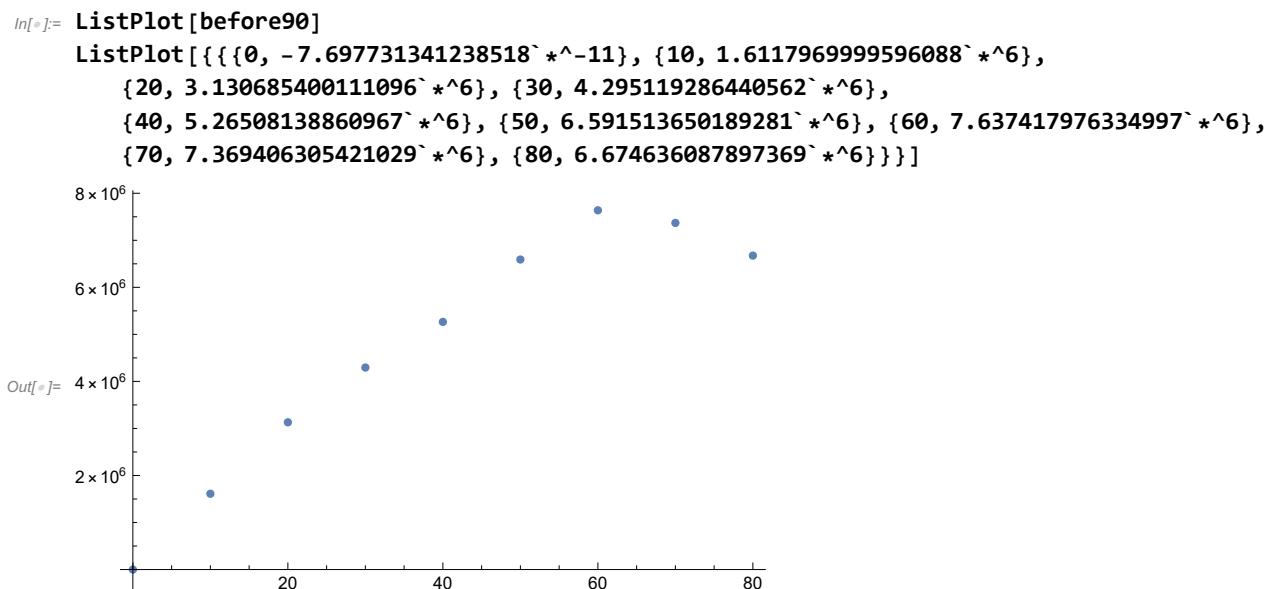
In this section, we define the functions that we use to obtain the righting moment that is acting on the boat. Waterline Angle > 90 Degrees

```
In[=]:= Submergedmore90[θθ_] := Module[{ },
  mass = 1315;
  com = {0, 3.25, 0};
  water = ImplicitRegion[
    y > Tan[θθ Degree] * x + d && -15 < x < 15 && -30 < y < 100 && -30 <= z <= 30, {x, y, z}];
  under = RegionIntersection[boat, water];
  disp = Integrate[1, {x, y, z} ∈ under /. {θ → θθ}];
  draft = N[d /. FindRoot[disp == mass, {d, -20, 20}][[1]]];
  cob = RegionCentroid[under /. {d → draft, θ → θθ}];
  buoyancy = mass * 980 * {-Sin[θθ Degree], Cos[θθ Degree], 0};
  torque = Cross[cob - com, buoyancy][[3]];
  torque
]

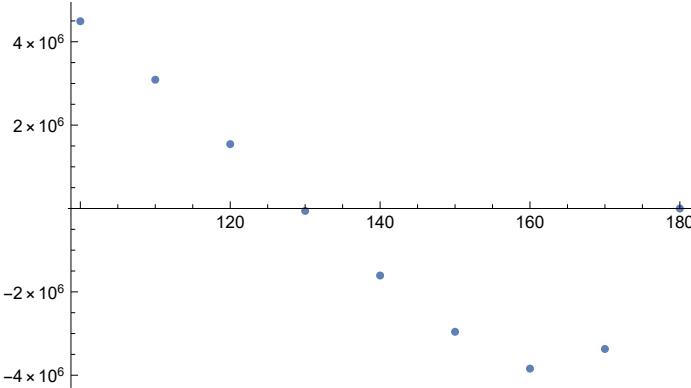
In[=]:= before90 =
  Table[{theta, Submergedless90[theta]}, {theta, {0, 10, 20, 30, 40, 50, 60, 70, 80}}]
Out[=]= {{0, -7.69773 × 10-11}, {10, 1.6118 × 106}, {20, 3.13069 × 106},
  {30, 4.29512 × 106}, {40, 5.26508 × 106}, {50, 6.59151 × 106},
  {60, 7.63742 × 106}, {70, 7.36941 × 106}, {80, 6.67464 × 106}}

In[=]:= after90 = Table[{theta, Submergedmore90[theta]}, {theta, {100, 110, 120, 130, 140, 150, 160, 170, 180}}]
Out[=]= {{100, 4.49229 × 106}, {110, 3.08922 × 106}, {120, 1.54417 × 106},
  {130, -57597.4}, {140, -1.60825 × 106}, {150, -2.95807 × 106},
  {160, -3.84148 × 106}, {170, -3.37014 × 106}, {180, 2.01158 × 10-11}}
```

In this section, we find and plot the results.



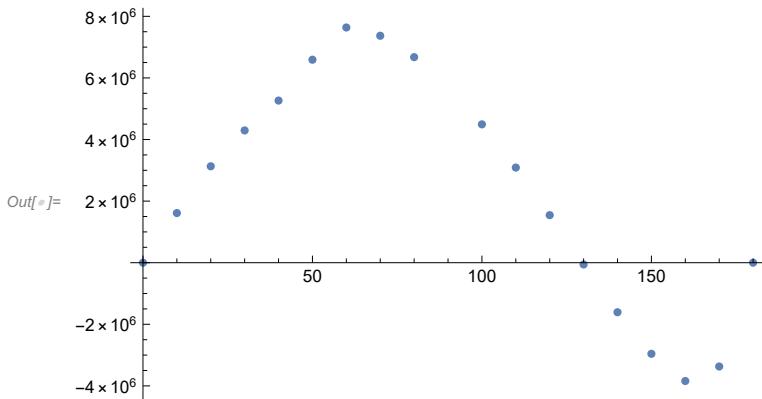
```
In[6]:= ListPlot[{{100, 4.492285882425818`*^6},
{110, 3.0892233977019624`*^6}, {120, 1.5441742377184266`*^6},
{130, -57597.35070126683`}, {140, -1.6082452983155984`*^6},
{150, -2.958066348619032`*^6}, {160, -3.8414826675554756`*^6},
{170, -3.370135743164603`*^6}, {180, 2.0115779159578246`*^-11}}]
```



```
In[7]:= AVS = {{0, -7.697731341238518`*^-11}, {10, 1.6117969999596088`*^6},
{20, 3.130685400111096`*^6}, {30, 4.295119286440562`*^6}, {40, 5.26508138860967`*^6},
{50, 6.591513650189281`*^6}, {60, 7.637417976334997`*^6}, {70, 7.369406305421029`*^6},
{80, 6.674636087897369`*^6}, {100, 4.492285882425818`*^6},
{110, 3.0892233977019624`*^6}, {120, 1.5441742377184266`*^6},
{130, -57597.35070126683`}, {140, -1.6082452983155984`*^6},
{150, -2.958066348619032`*^6}, {160, -3.8414826675554756`*^6},
{170, -3.370135743164603`*^6}, {180, 2.0115779159578246`*^-11}}
```

```
Out[7]= {{0, -7.69773 \times 10^{-11}}, {10, 1.6118 \times 10^6}, {20, 3.13069 \times 10^6},
{30, 4.29512 \times 10^6}, {40, 5.26508 \times 10^6}, {50, 6.59151 \times 10^6}, {60, 7.63742 \times 10^6},
{70, 7.36941 \times 10^6}, {80, 6.67464 \times 10^6}, {100, 4.49229 \times 10^6}, {110, 3.08922 \times 10^6},
{120, 1.54417 \times 10^6}, {130, -57597.4}, {140, -1.60825 \times 10^6}, {150, -2.95807 \times 10^6},
{160, -3.84148 \times 10^6}, {170, -3.37014 \times 10^6}, {180, 2.01158 \times 10^{-11}}}
```

```
In[6]:= ListPlot[{{0, -7.697731341238518`*^-11}, {10, 1.6117969999596088`*^6}, {20, 3.130685400111096`*^6}, {30, 4.295119286440562`*^6}, {40, 5.26508138860967`*^6}, {50, 6.591513650189281`*^6}, {60, 7.637417976334997`*^6}, {70, 7.369406305421029`*^6}, {80, 6.674636087897369`*^6}, {100, 4.492285882425818`*^6}, {110, 3.0892233977019624`*^6}, {120, 1.5441742377184266`*^6}, {130, -57597.35070126683`}, {140, -1.6082452983155984`*^6}, {150, -2.958066348619032`*^6}, {160, -3.8414826675554756`*^6}, {170, -3.370135743164603`*^6}, {180, 2.0115779159578246`*^-11}}]
```



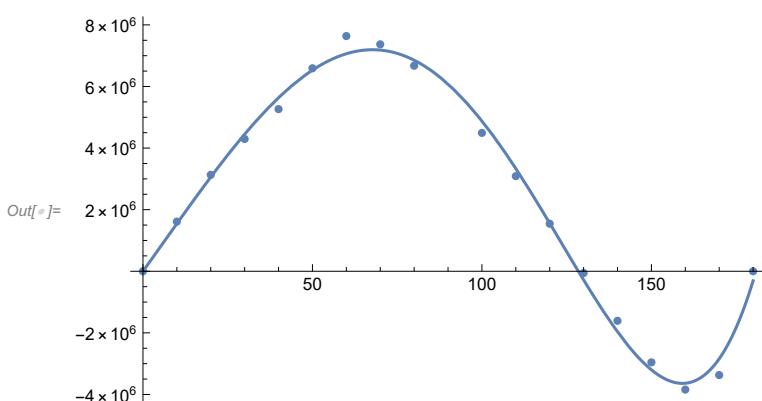
```
In[7]:= curve = A*x^5 + B*x^4 + C*x^3 + D*x^2 + F*x
params = {{A}, {B}, {C}, {D}, {F}}
bestparams = FindFit[AVS, curve, params, x]
bestcurve = curve /. bestparams
Show[ListPlot[AVS], Plot[bestcurve, {x, 0, 180}]]
```

```
Out[7]= F x + D x^2 + C x^3 + B x^4 + A x^5
```

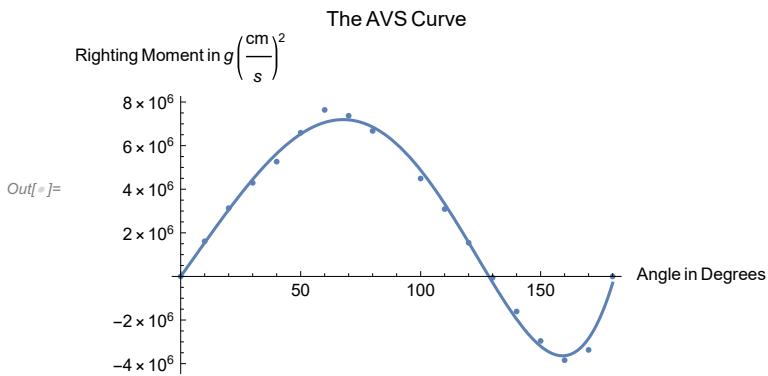
```
Out[8]= {{A}, {B}, {C}, {D}, {F}}
```

```
Out[9]= {A → 0.000475537, B → -0.0485358, C → -12.8235, D → 245.067, F → 153503.}
```

```
Out[10]= 153503. x + 245.067 x^2 - 12.8235 x^3 - 0.0485358 x^4 + 0.000475537 x^5
```



```
In[6]:= Show[%36, AxesLabel -> {HoldForm[Angle in Degrees], HoldForm[Righting Moment in g \left(\frac{cm}{s}\right)^2]}, PlotLabel -> HoldForm[The AVS Curve], LabelStyle -> {GrayLevel[0]}]
```



The analytical value of our AVS = 130 Degrees