Reactions

Exercise 4.C1

The plan here is to abstract the reaction solver, to *hopefully* solve a system of reactions, by invoking equilibrium (assuming statically determinate; though I suppose that statically indeterminate will just return no solution.)

To this we abstract every force to a magnitude, direction, and location.

```
fArbitrary = {"Label", fArbMag, {dx, dy, dz}, {cx, cy, cz}}
```

{Label, fArbMag, {dx, dy, dz}, {cx, cy, cz}}

Now the problem:

We first make a list of all of the forces. We can immediately get the equations for the sum of the forces (in x and y) and the sum of the moments about the origin (point A in this case).

```
Clear[tMag, aXMag, AYMag, theta]

forceList4C1 = {

{"PLoad", Quantity[50, "Pounds"], {0, −1, 0},

Simplify[{27 ∗ Sin[theta] + 4 ∗ Cos[theta], −27 ∗ Cos[theta] + 4 ∗ Sin[theta], 0}]},

{"Tension E", tMag, Normalize[{8 − 12 ∗ Sin[theta], 16 + 12 ∗ Cos[theta], 0}],

{12 ∗ Sin[theta], −12 ∗ Cos[theta], 0}},

(*{"Tension E", tMag, {0, 1, 0}, {12 ∗ Sin[theta], −12 ∗ Cos[theta], 0}}, *)

{"Ax Reaction", aXMag, {1, 0, 0}, {0, 0, 0}},

{"Ay Reaction", aYMag, {0, 1, 0}, {0, 0, 0}}(*,

{"Gravity Bar", gravMag, {dGx, dGy, 0}, {27 ∗ Sin[theta], 27 ∗ Cos[theta], 0}}*)

};


numForces = Length[forceList4C1];

forceNet = Sum[forceList4C1[[i]][[2]] ∗ forceList4C1[[i]][[3]], {i, 1, numForces}]

momentNet =

Sum[forceList4C1[[i]][[2]] ∗ ((forceList4C1[[i]][[4]]) × forceList4C1[[i]][[3]]),

{i, 1, numForces}]
```

$$\left\{\text{aXMag} + + \frac{\text{tMag}(8-12\text{Sin[theta]})}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}}, \text{aYMag} + \frac{\text{tMag}(16+12\text{Cos[theta]})}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}} +, \right\}$$

$$\left\{, , ()(-4\text{Cos[theta]} - 27\text{Sin[theta]}) + \text{tMag}\left(\frac{96\text{Cos[theta]}}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}} + \frac{192\text{Sin[the}}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{A}}}\right.\right.$$

Invoking Equilibrium, sum of forces and sum of moments equal the zero vectors

StringForm["Invoking Equilibrium, sum of forces and sum of moments"]

Solve[forceNet == {0, 0, 0}, {aXMag, aYMag}]

Solve[momentNet == {0, 0, 0}, {tMag}]

StringForm["Converting to a table"]

sol4C1Flat = Table[

Flatten[

{theta ∗ $\frac{180}{\pi}$, {tMag, aXMag, aYMag}/.

Solve[forceNet == {0, 0, 0}&&momentNet == {0, 0, 0}, {tMag, aXMag, aYMag}]}],

{theta, 0, 120 ∗ $\frac{\pi}{180}$, 10 ∗ $\frac{\pi}{180}$}] ;

***N*[sol4C1Flat]**

Invoking Equilibrium, sum of forces and sum of moments

$$\left\{\left\{\text{aXMag} \to -\frac{8\text{tMag}}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}} + \frac{12\text{tMagSin[theta]}}{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}}, \text{aYMag} \to -\right.\right.$$

$$\left\{\left\{\text{tMag} \to \frac{\sqrt{\text{Abs}[16+12\text{Cos[theta]}]^2+\text{Abs}[8-12\text{Sin[theta]}]^2}()(4\text{Cos[theta]}+27\text{Sin[theta]})}{\text{Cos[theta]}+2\text{Sin[theta]}}\right\}\right\}$$

Converting to a table

{{0., , , }, {10., , , }, {20., , , }, {30., , , }, {40., , , }, {50., , , }, {60., , , }, {70., , , }, {80., , , }, {90., , , }, {100., , , }, {110., ,

We separate the values into different lists and plot the result

thetaDegVals = sol4C1Flat[[1;;, 1]];

tMagVals = sol4C1Flat[[1;;, 2]];

aXMagVals = *N*[sol4C1Flat[[1;;, 3]]];

```
aYMagVals = N[sol4C1Flat[[1;;, 4]]];
thetaCrit = ArcSin[8/12] * 180/π;
N[thetaCrit]
ListLinePlot[Flatten[{thetaDegVals, tMagVals}, {{2}, {1}}],
AxesLabel → {"Angle from Vertical", "Tension force"}, PlotRange → All,
PlotMarkers → {Automatic, 10}]
```

41.8103

To check our angles, we can plot the location of the tension force and the load. (It follows the bar movement as a function of theta.

```
endofLrod =
N[Table[{theta * 180/π, 27 * Sin[theta] + 4 * Cos[theta], −27 * Cos[theta] + 4 * Sin[theta]},
{theta, 0, 120 * π/180, 10 * π/180}]]
endofLrod[[1;;, 2;;3]];
midofRod =
N[Table[{theta * 180/π, 12 * Sin[theta], −12 * Cos[theta]}, {theta, 0, 120 * π/180, 10 * π/180}]];
ListPlot[{endofLrod[[1;;, 2;;3]], midofRod[[1;;, 2;;3]]}, AspectRatio → Automatic,
AxesLabel → {"X Direction", "Y Direction"}, PlotMarkers → {Automatic, 10}]
```

{{0., 4., −27.}, {10., 8.62773, −25.8952}, {20., 12.9933, −24.0036}, {30., 16.9641, −21.3827}, {40., 20.4194, −18.1