```
SetDirectory[NotebookDirectory[]]
```

```
G:\nabbasi\data\nabbasi_web_Page\my_courses\univ_wisconsin_madison\spring_2014\EMA_523
  _flight_dynamics_and_control\HWs\HW1
```

Appendix

worksheet used for calculations for HW1, EMA 523

by Nasser M. Abbasi

This is an appendix for HW1, EMA 523, University of wisconsin, Madison. This includes all calculations when working on HW1. Added as an appendix. Software used is *Mathematica* 9.01

---

function to find c(y)

```
chordLength[y_, s_, b_, lambda_] := 2 s/((1 + lambda) b) (1 - 2 (1 - lambda)/b y)
```

```
Clear[y];
s = 2775;
b = 150;
lambda = 0.48;
c = chordLength[y, s, b, lambda]
```

```
25. (1 - 0.00693333 y)
```

```
cBar = 2/s Integrate[c^2, {y, 0, b/2}]
```

```
19.2613
```

```
yBar = 2/s Integrate[c y, {y, 0, b/2}]
```

```
33.1081
```

```
zBar = 2/s Integrate[c y Tan[4 Degree], {y, 0, b/2}]
```

```
2.31514
```

```
xBar = 2/s Integrate[c ((1/4) c + y * Tan[26 Degree]), {y, 0, b/2}]
```

```
20.9632
```

---

problem 1

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top view

```
cr = 25;
b = 150;
ct = 12;

leadEdgeSweep = 26 Degree;
dihedralAngle = 4 Degree;
z = b / 2 * Tan[leadEdgeSweep];
{"tapper Ration=", (tapperRatio = ct / cr) // N}
{"x=", (x = (b / 2) (1 / 3) (1 + 2 tapperRatio) / (1 + tapperRatio) Tan[leadEdgeSweep]) // N}
{"averageChord", (averageChord = (cr + ct) / 2) // N}
{"area S=", (s = b * averageChord) // N}
{"aspectRatio", (aspectRatio = b^2 / s) // N}
{"cBar=",
 (cBar = x / (aspectRatio Tan[leadEdgeSweep]) * 8 (1 + tapperRatio + tapperRatio^2) / ((1 + 2 tapperRatio) (1 + tapperRatio))) // N}
{"y=", (y = x Tan[Pi / 2 - leadEdgeSweep]) // N}
{"xac=", (xac = x + 1 / 4 cBar) // N}
{"Length of top edge=", (lenTop = (b / 2) / Cos[26 Degree]) // N}


img = Graphics[
  {
   {EdgeForm[Black], RGBColor[.99, .98, .98], Polygon[{
      {0, cr / 2},
      {b / 2, cr / 2 - z},
      {b / 2, cr / 2 - z - ct},
      {0, -cr / 2},
      {-b / 2, cr / 2 - z - ct},
      {-b / 2, cr / 2 - z}
     }]},
   (*{Dashed,Line[{{0,cr/2-z},{b/2,cr/2-z}}]},*)
   {Dashed, Line[{{0, cr / 2}, {0, cr / 2 - x}}]},
   {Thick, Red, Line[{{0, cr / 2 - x}, {0, cr / 2 - x - cBar}}]},

   {Dashed, Line[{{0, cr / 2 - x}, {y, cr / 2 - x}}]},
   {Dashed, Line[{{y, cr / 2 - x}, {y, cr / 2 - x - cBar}}]},

   {EdgeForm[Black], FaceForm[White], Disk[{0, cr / 2 - 16.148 - 4.815}, 1]}, (*ac*)
   {EdgeForm[Black], FaceForm[White], Disk[{0, -cr / 2}, .5]},
   {EdgeForm[Black], FaceForm[White],
    Disk[{0, cr / 2 - 16.148 - 4.815 - 4.037 - 2 * 0.9631}, .5]},

   {Dashed, Line[{{0, cr / 2 - x - cBar}, {y, cr / 2 - x - cBar}}]},
```

```
    {EdgeForm[Black], FaceForm[White], Disk[{y, cr / 2 - xac}, 1]},

    {Dashed, Line[{{-y, cr / 2 - x}, {-y, cr / 2 - x - cBar}}]},
    {Dashed, Line[{{0, cr / 2 - x}, {-y, cr / 2 - x}}]},
    {EdgeForm[Black], FaceForm[White], Disk[{-y, cr / 2 - xac}, 1]},
    {Dashed, Line[{{0, cr / 2 - x - cBar}, {-y, cr / 2 - x - cBar}}]},
   },

   Axes → False, ImageSize → 600
  ]
```

{tapper Ration=, 0.48}

{x=, 16.1479}

{averageChord, 18.5}

{area S=, 2775.}

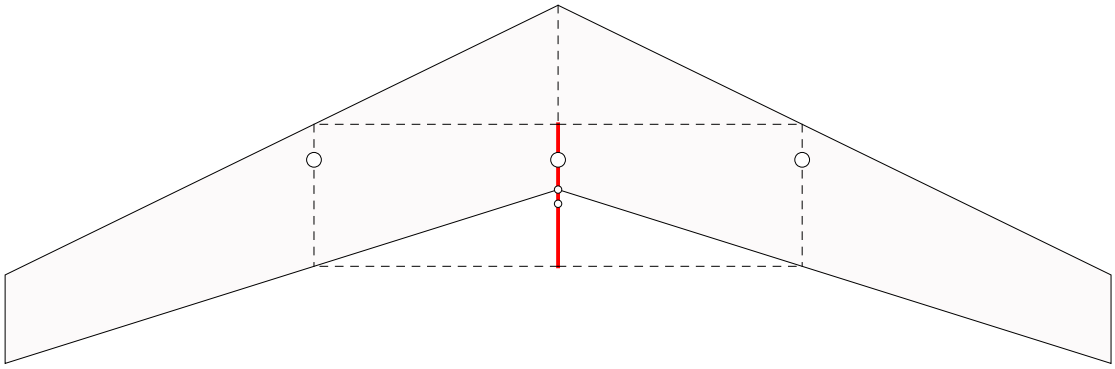
{aspectRatio, 8.10811}

{cBar=, 19.2613}

{y=, 33.1081}

{xac=, 20.9632}

{Length of top edge=, 83.4451}



```
Export["imag1.eps", img]
```

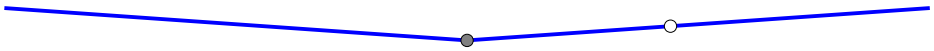
imag1.eps

side-view

```
Graphics[
 {
  {Blue, Thick, Line[{{0, 0}, {cr, 0}}]},
  {Black, Thick, Line[{{16.148, .5}, {16.148 + 19.261, 0.5}}]},
  {EdgeForm[Black], FaceForm[White], Disk[{16.148 + 4.815, .5}, .25]},
  {EdgeForm[Black], FaceForm[Red], Disk[{cr, .5}, .25]},
  {EdgeForm[Black], FaceForm[Blue], Disk[{16.148 + 9.815, .5}, .25]}
  (*{EdgeForm[Black],FaceForm[White],Disk[{16.148+4.815+55,.5},.25]}*)
 },
 Axes → False, ImageSize → 500, AspectRatio → Automatic
]
```

front view

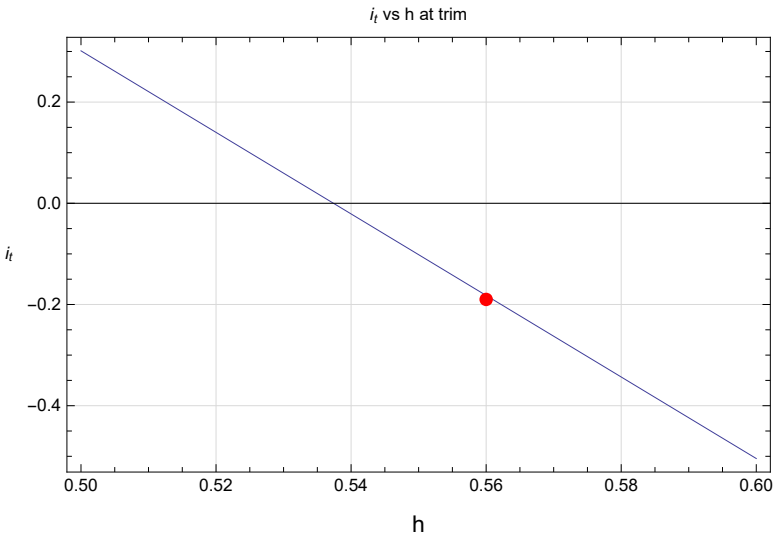
```
Graphics[
 {
  {Blue, Thick, Line[{{0, 0}, {b / 2 Cos[dihedralAngle] , b / 2 Sin[dihedralAngle]}}]},
  {Blue, Thick, Line[{{0, 0}, {-b / 2 Cos[dihedralAngle] , b / 2 Sin[dihedralAngle]}}]},
  {EdgeForm[Black], FaceForm[Gray], Disk[{0, 0}, 1]},
  {EdgeForm[Black], FaceForm[White],
   Disk[{33.108 Cos[dihedralAngle], 33.108 Sin[dihedralAngle]}, 1]}
 },
 Axes → False, ImageSize → 500, AspectRatio → Automatic
]
```



problem 3

```
it = 4.3294 - 8.0563 h
p = Plot[it, {h, 0.5, 0.6}, PlotRange → All, Frame → True,
   FrameLabel → {{"i_t", None}, {Style["h", 12], "i_t vs h at trim"}},
   GridLines → Automatic, GridLinesStyle → LightGray, ImageSize → 400,
   Epilog → {Red, PointSize[Large], Point[{0.56, -0.19}]}, RotateLabel → False]
```

```
4.3294 - 8.0563 h
```



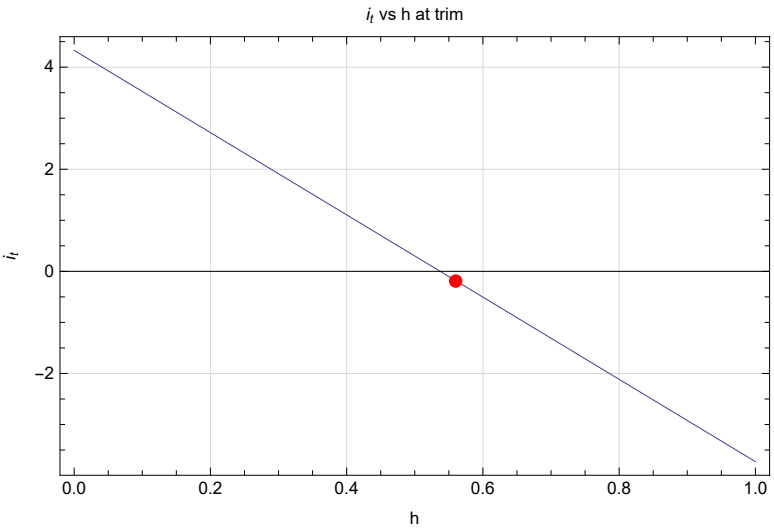

```
Export["problem_3_part_b_plot.eps", p]
Export["problem_3_part_b_plot.pdf", p]
```

```
problem_3_part_b_plot.eps
```

```
problem_3_part_b_plot.pdf
```

```
it = 4.3294 - 8.0563 h
p = Plot[it, {h, 0, 1}, PlotRange → All,
  Frame → True, FrameLabel → {{"$i_t$", None}, {"h", "$i_t$ vs h at trim"}},
  GridLines → Automatic, GridLinesStyle → LightGray, ImageSize → 400,
  Epilog → {Red, PointSize[Large], Point[{0.56, -0.19}]}]
```

```
4.3294 - 8.0563 h
```




```
Export["problem_3_part_b_plot_2.eps", p]
Export["problem_3_part_b_plot_2.pdf", p]
```

```
problem_3_part_b_plot_2.eps
```

```
problem_3_part_b_plot_2.pdf
```

problem 5

The table in the problem is defined to use for plotting

```
mat1 = {{40.7, 1656, 1.5, 2.385},
    {48.7, 1650, 0, 2.385},
    {56.3, 1649, -1.0, 2.385},
    {69.3, 1646, -2, 2.385}};
mat2 = {{39.8, 1466, 4.5, 2.205},
    {46.9, 1463, 2, 2.205},
    {55.0, 1461, 0.3, 2.205},
    {67.5, 1458, -1, 2.205}};
mat3 = {{38.9, 1293, 7.2, 2.043},
    {46, 1290, 3.5, 2.043},
    {54.5, 1288, 1.5, 2.043},
    {68, 1286, 0, 2.043}};
```

Function defined to calculate C_L and generate the plots

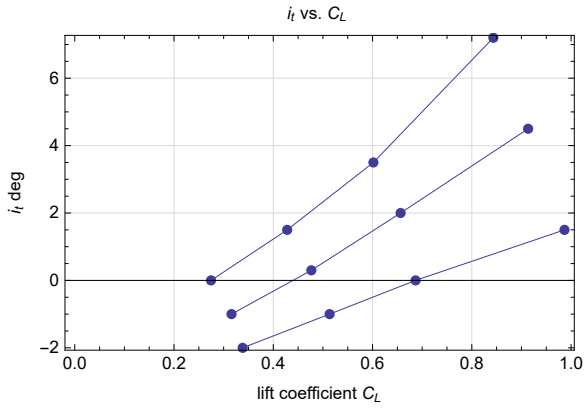
```
cl[v_, m_] := Module[{g = 9.8, area = 16.21, density = 1.225},
    m g
   ----------------------
   1/2 density v^2 area
  ];
(*makeData[mat_]:=Module[{clValues},
   clValues=cl[#[[1]],#[[2]]]&/@mat[[All,{1,2}]];
   Transpose[{mat[[All,3]],clValues}]
  ];*)
makeData[mat_] := Module[{clValues},
   clValues = cl[#[[1]], #[[2]]] & /@ mat[[All, {1, 2}]];
   Transpose[{clValues, mat[[All, 3]]}]
  ];
makePlot[mat_] := ListLinePlot[makeData[mat],
  Mesh → All,
  AxesOrigin → {0, 0},
  PlotStyle → PointSize[.02],
  Frame → True,
  (*FrameLabel→{{"lift coefficient C_L",None},{"i_t deg",Defer["C_L vs. i_t"]}},*)
  FrameLabel → {{"i_t deg", None}, {"lift coefficient C_L", "i_t vs. C_L "}},
  GridLines → Automatic, GridLinesStyle → LightGray
 ]
```

```
makeData[#] & /@ {mat1[[All, {1, 2, 3}]], mat2[[All, {1, 2, 3}]], mat3[[All, {1, 2, 3}]]};
Flatten[%, 1];
g = Grid[Join[{{"C_Ltrim", "i_t (degree)"}}, %], Frame → All, Alignment → Left]
```

$C_{L_{trim}}$	i_t (degree)
0.986753	1.5
0.686694	0
0.5135	−1.
0.338299	−2
0.913492	4.5
0.656501	2
0.476718	0.3
0.315854	−1
0.843405	7.2
0.601743	3.5
0.428016	1.5
0.274511	0

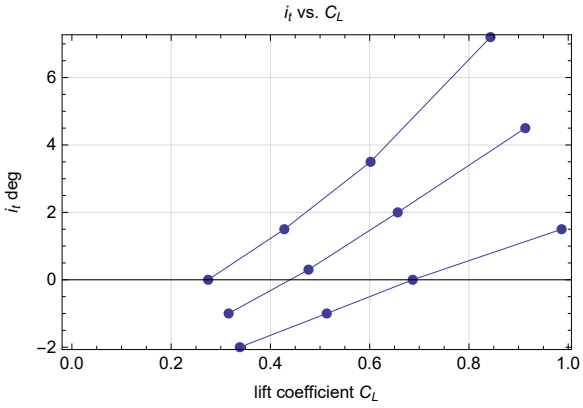
Part (a)

```
makePlot[#] & /@ {mat1[[All, {1, 2, 3}]], mat2[[All, {1, 2, 3}]], mat3[[All, {1, 2, 3}]]};
p = Show[%, PlotRange → All, ImageSize → 300]
```




```
g1 = Grid[{{g, p}}]
```

$C_{L_{trim}}$	i_t (degree)
0.986753	1.5
0.686694	0
0.5135	−1.
0.338299	−2
0.913492	4.5
0.656501	2
0.476718	0.3
0.315854	−1
0.843405	7.2
0.601743	3.5
0.428016	1.5
0.274511	0




```
Export["table_part_a_problem_5.eps", g1]
Export["table_part_a_problem_5.pdf", g1]
```

```
table_part_a_problem_5.eps
```

```
table_part_a_problem_5.pdf
```

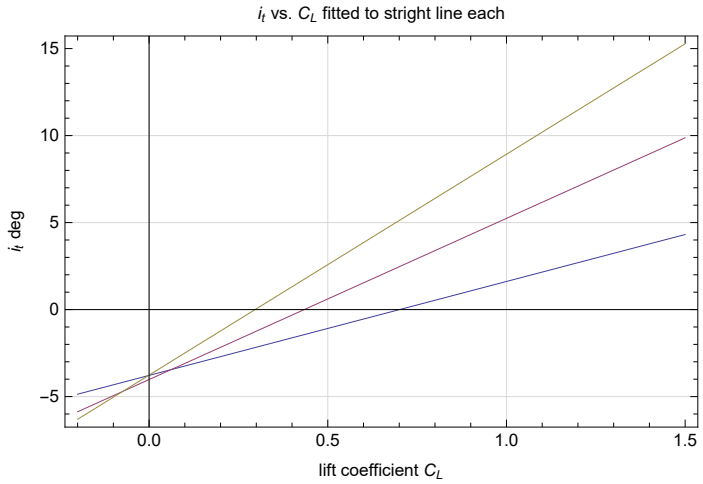
part (b)

Fit to a line

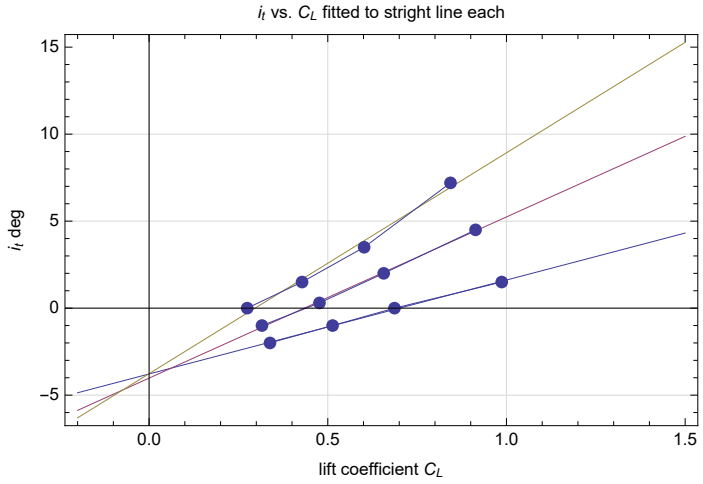
```
Clear[x];
s = Fit[#, {1, x}, x] & /@ {makeData@mat1[[All, {1, 2, 3}]],
    makeData@mat2[[All, {1, 2, 3}]], makeData@mat3[[All, {1, 2, 3}]]}
```

$$\{-3.78307 + 5.3984\,x,\ -4.02058 + 9.2621\,x,\ -3.76524 + 12.6932\,x\}$$

```
p2 = Plot[s, {x, -.2, 1.5},
  AxesOrigin → {0, 0},
  Frame → True,
  (*FrameLabel→{{"lift coefficient C_L",None},
    {"i_t deg",Defer["C_L vs. i_t fitted to stright line each"]}},*)
  FrameLabel → {{"i_t deg", None}, {"lift coefficient C_L",
     "i_t vs. C_L fitted to stright line each"}},
  GridLines → Automatic, GridLinesStyle → LightGray
 ]
```




```
tmp = Show[p2, p]
```




```
Export["problem_5_part_b.eps", tmp]
Export["problem_5_part_b.pdf", tmp]
```

```
problem_5_part_b.eps
```

```
problem_5_part_b.pdf
```

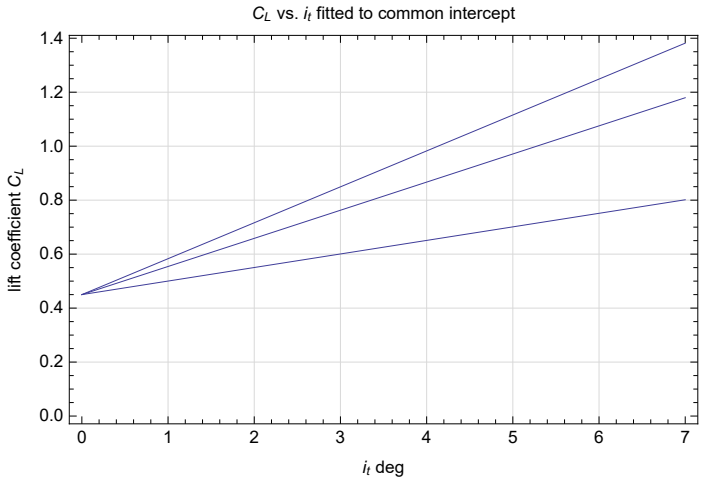
DO NOT USE BELOW, trying different things

Fit each date to $y = m + c\,x$ where $m = 0.45$ selected as common intercept

```
s = FindFit[#, .45 + c x, c, x] & /@ {makeData@mat1[[All, {1, 2, 3}]],
    makeData@mat2[[All, {1, 2, 3}]], makeData@mat3[[All, {1, 2, 3}]]}
```

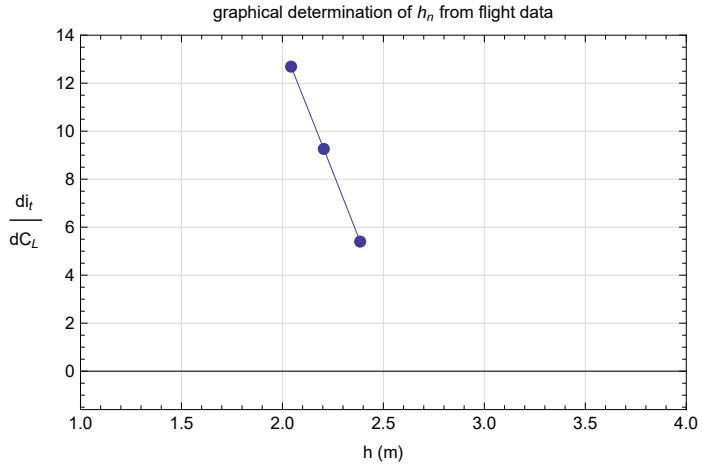
```
{{c → 0.133108}, {c → 0.104218}, {c → 0.0502056}}
```

```
Plot[(.45 + c x) /. s, {x, 0, 7},
 AxesOrigin → {0, 0},
 Frame → True,
 FrameLabel → {{"lift coefficient C_L", None},
   {"i_t deg", Defer["C_L vs. i_t fitted to common intercept"]}},
 GridLines → Automatic, GridLinesStyle → LightGray
]
```



Part (c)

```
data = {{2.385, 5.4}, {2.205, 9.26}, {2.043, 12.69}};
p1 = ListLinePlot[data,
  Mesh → All,
  AxesOrigin → {0, 0},
  PlotStyle → PointSize[.02],
  Frame → True,
  FrameLabel →
   {{"di_t/dC_L", None}, {"h (m)", "graphical determination of h_n from flight data"}},
  GridLines → Automatic, GridLinesStyle → LightGray,
  PlotRange → {{1, 4}, {-1.6, 14}}, RotateLabel → False]
```



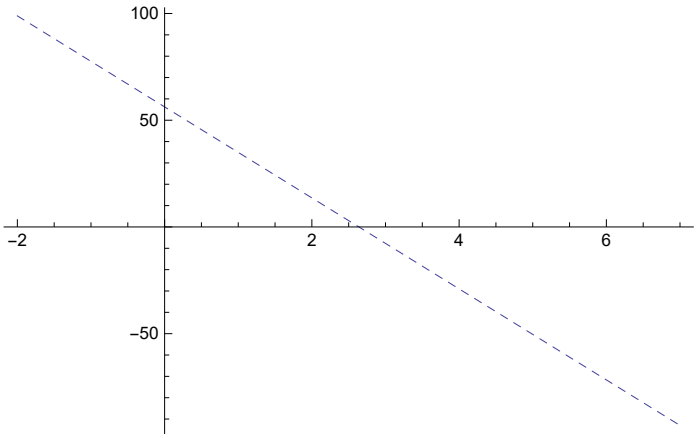

```
Export["problem_5_part_c_1.eps", p1]
Export["problem_5_part_c_1.pdf", p1]
```

problem_5_part_c_1.eps

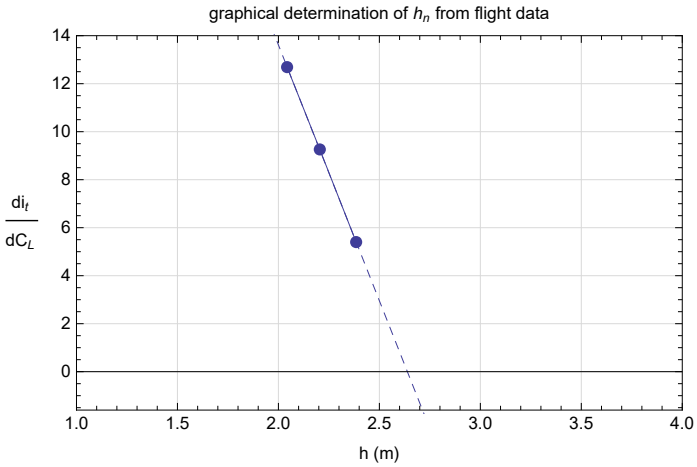
problem_5_part_c_1.pdf

```
s = Fit[data, {1, x}, x]
p2 = Plot[s, {x, -2, 7}, PlotStyle → Dashed]
```

56.2511 – 21.3182 x




```
tmp = Show[p1, p2]
```




```
Export["problem_5_part_c_2.eps", tmp]
Export["problem_5_part_c_2.pdf", tmp]
```

problem_5_part_c_2.eps

problem_5_part_c_2.pdf