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> interface(rtalsize=20):# Display up to 20x20 matrices
> with(LinearAlgebra):
> # Problem 1, Lab 2: Traffic Flow
> # 12 intersections, 12 equations in 17 unknowns.
# Enter equations. Shift-Enter extends input. Ctrl-K opens a line
above.
# RED is your input. BLUE is formatted output from the maple
engine.
> #
# FIGURE 1 CORRECTIONS:
#
# UNIVERSITY: 7598 should be 7593.
# The original LAB 2 has been documented, then replaced online.

> eq[1]:=18144+x[4]=10475+x[1];eq[2]:=x[1]+16680=x[5]+x[2];eq[3]:=x
[2]+x[6]=7593+x[3];eq[4]:=x[3]+9462=18820+x[7];
    eq1 := 18144 + x4 = 10475 + x1
    eq2 := x1 + 16680 = x5 + x2
    eq3 := x2 + x6 = 7593 + x3
    eq4 := x3 + 9462 = 18820 + x7 (1)

> eq[5]:=x[11]+x[8]=19929+x[4];eq[6]:=x[5]+x[9]=x[8]+x[12];eq[7]:=x
[13]+x[10]=x[6]+x[9];eq[8]:=x[7]+15089=x[10]+x[14];
    eq5 := x11 + x8 = 19929 + x4
    eq6 := x5 + x9 = x8 + x12
    eq7 := x13 + x10 = x6 + x9
    eq8 := x7 + 15089 = x10 + x14 (2)

> eq[9]:=4571+6998=x[15]+6433+x[11];eq[10]:=x[15]+x[12]=8080+x[16];
eq[11]:=x[16]+5379=x[13]+x[17];eq[12]:=6049+x[14]+x[17]=
5648+5394;
    eq9 := 11569 = x15 + 6433 + x11
    eq10 := x15 + x12 = 8080 + x16
    eq11 := x16 + 5379 = x13 + x17
    eq12 := 6049 + x14 + x17 = 11042 (3)

> eqs:=[seq(eq[i],i=1..12)];var:=[seq(x[j],j=1..17)];
eqs:= [18144 + x4 = 10475 + x1, x1 + 16680 = x5 + x2, x2 + x6 = 7593 + x3, x3
+ 9462 = 18820 + x7, x11 + x8 = 19929 + x4, x5 + x9 = x8 + x12, x13 + x10 = x6
+ x9, x7 + 15089 = x10 + x14, 11569 = x15 + 6433 + x11, x15 + x12 = 8080
+ x16, x16 + 5379 = x13 + x17, 6049 + x14 + x17 = 11042]
var:=[x1, x2, x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15, x16, x17] (4)

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> # Define augmented matrix of the equations
C1:=GenerateMatrix(eqs,var,augmented);
C1:=
[[ -1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -7669],
[1, -1, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -16680],
[0, 1, -1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 7593],
[0, 0, 1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 9358],
[0, 0, 0, -1, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 19929],
[0, 0, 0, 0, 1, 0, 0, -1, 1, 0, 0, -1, 0, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 0, -1, 0, 0, -1, 1, 0, 0, 1, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 0, 1, 0, 0, -1, 0, 0, -1, 0, 0, 0, -15089],
[0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, -5136],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, -1, 0, 8080],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 1, -1, -5379],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 4993]]

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> # Load augmented matrix C from the lab, printed there in RED as matrix A

All lead positions are 1, because they did the conversion to matrices by hand.

The original lab RED print is incorrect, change -1 in row 12 to 1.

FIGURE 1 has one error:

UNIVERSITY: 7598 should be 7593.

In 2016, google maps shows THIRD is bidirectional traffic.

Variables x[15],x[16],x[17]

represent positive or negative net traffic counts.

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> C := Matrix( # Corrected -1 in row 12
> [ [ 1, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
7669],
> [ 1, -1, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
-16680],
> [ 0, 1, -1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
7593],
> [ 0, 0, 1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
9358],
> [ 0, 0, 0, 1, 0, 0, 0, -1, 0, 0, -1, 0, 0, 0, 0, 0,
-19929],
> [ 0, 0, 0, 0, 1, 0, 0, -1, 1, 0, 0, -1, 0, 0, 0, 0,
0],
> [ 0, 0, 0, 0, 0, 1, 0, 0, 1, -1, 0, 0, -1, 0, 0, 0,
0],
> [ 0, 0, 0, 0, 0, 0, 1, 0, 0, -1, 0, 0, 0, -1, 0, 0,
-15089],
> [ 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0,
0]

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> [ 5136,
  >   [ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, -1, 0,
  > 8080],
  >   [ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, -1, 1,
  > 5379],
  >   [ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1,
  > 4993] ] );

```

$$C := \begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 7669 \\ 1 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -16680 \\ 0 & 1 & -1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 7593 \\ 0 & 0 & 1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 9358 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & -19929 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & -15089 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 5136 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & -1 & 0 & 8080 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 & 1 & 5379 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 4993 \end{bmatrix} \quad (6)$$

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> # The two augmented matrices differ, because of leading elements
  in rows 1,5,7,9,11. Re-scale.
> with(linalg):
> C2:=scale(C1,1,-1):C3:=scale(C2,5,-1):C4:=scale(C3,7,-1):C5:=
  scale(C4,9,-1):C6:=scale(C5,11,-1):
> C-C6;# Should be zero if C equals C6.

```

(7)

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (7)$$

> **ans:=LinearSolve(C,free='t');** # Solve the augmented system for x

$$ans := \begin{bmatrix} -7124 + t_8 - t_{15} \\ 1476 + t_9 - t_{16} \\ -738 + t_{10} - t_{17} \\ -14793 + t_8 - t_{15} \\ 8080 + t_8 - t_9 - t_{15} + t_{16} \\ 5379 - t_9 + t_{10} + t_{16} - t_{17} \\ -10096 + t_{10} - t_{17} \\ t_8 \\ t_9 \\ t_{10} \\ 5136 - t_{15} \\ 8080 - t_{15} + t_{16} \\ 5379 + t_{16} - t_{17} \\ 4993 - t_{17} \\ t_{15} \\ t_{16} \\ t_{17} \end{bmatrix} \quad (8)$$

Problem 1, Part (d): (i) Do more cars travel northbound or southbound between Pike St and Union St?

Variable $x[15]$ is signed net flow, but variables $x[1]$, $x[8]$ are positive directional flow. The northbound flow is $x[8]$. The southbound flow is $x[1]+x[15]$. These two flows should be nonnegative.

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> ans[1]+ans[15]; ans[8];
# The flow x[8] is greater, so northbound has the most traffic
```

$$-7124 + t_8$$

$$t_8 \quad (9)$$

```
> # It is possible to find a vector basis for the solution space of
   the homogenous equation.
# To do this, identify the free variable symbols and then compute
vector partial derivatives.
#strangSolution:=(ans,n)->map(x->diff(x,t[n]),ans);seq
(strangSolution(ans,j),j in [8,9,10,15,16,17]);
```