



(5)

```
> # 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,-1,0,0,0,1,0,0,1,0,0,0,0,0,19929],
[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,-1,0,0,0,-15089],
[0,0,0,0,0,0,0,0,0,0,-1,0,0,0,-1,0,0,-5136],
[0,0,0,0,0,0,0,0,0,0,0,1,0,0,1,-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]]

> # 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.

> C := Matrix( # Corrected -1 in row 12
> [ [ 1, 0, 0, -1, 0, 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, 0,
-16680],
> [ 0, 1, -1, 0, 0, 1, 0, 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, 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, 0, 1, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0,
-15089],
> [ 0, 0, 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, 0, 0, 0, 1, 0, 0, 1, -1, 0,
8080],
> [ 0, 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, 0, 1, 0, 0, 1,
4993] ] );

```

```

C:=
[ 1  0  0 -1  0  0  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  0  0 -16680
  0  1 -1  0  0  1  0  0  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  0  0  9358
  0  0  0  1  0  0  0 -1  0  0 -1  0  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  0  1  0  0  1 -1  0  0 -1  0  0  0  0  0  0
  0  0  0  0  0  0  1  0  0 -1  0  0  0 -1  0  0  0 -15089
  0  0  0  0  0  0  0  0  0  0  1  0  0  0  1  0  0  0  5136
  0  0  0  0  0  0  0  0  0  0  0  1  0  0  1 -1  0  0  8080
  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0 -1  1  0  5379
  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  1  0  4993

```

(6)

```

> # The two augmented matrices differ, because of leading elements
in rows 1,5,7,9,11. Re-scale.
> with(laylinalg):
> 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)

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

(7)

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

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

(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.

```
> ans[1]+ans[15]; ans[8];  
# The flow  $x[8]$  is greater, so northbound has the most traffic  
-7124 +  $t_8$   
 $t_8$  (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]);
```