# Assignment Instructions: Assignment 4

## Purpose

The purpose of this assignment is to formulate and solve a transportation / transshipment problem.

## Directions

1. Heart Start produces automated external defibrillators (AEDs) in each of two different plants (A and B). The unit production costs and monthly production capacity of the two plants are indicated in the table below. The AEDs are sold through three wholesalers. The shipping cost from each plant to the warehouse of each wholesaler along with the monthly demand from each wholesaler are also indicated in the table. How many AEDs should be produced in each plant, and how should they be distributed to each of the three wholesaler warehouses so as to minimize the combined cost of production and shipping?

| | *Unit Shipping Cost* | | | *Unit* | *Monthly* |
|---|---|---|---|---|---|
| | *Warehouse 1* | *Warehouse 2* | *Warehouse 3* | *Production Cost* | *Production Capacity* |
| *Plant A* | *$22* | *$14* | *$30* | *$600* | *100* |
| *Plant B* | *$16* | *$20* | *$24* | *$625* | *120* |
| *Monthly Demand* | *80* | *60* | *70* | | |

Formulate and solve this transportation problem using *lpsolve*, or any other equivalent library in R.

2. **Oil Distribution** Texxon Oil Distributors, Inc., has three active oil wells in a west Texas oil field. Well 1 has a capacity of 93 thousand barrels per day (TBD), Well 2 can produce 88 TBD, and Well 3 can produce 95 TBD. The company has five refineries along the Gulf Coast, all of which have been operating at stable demand levels. In addition, three pump stations have been built to move the oil along the pipelines from the wells to the refineries. Oil can flow from any one of the wells to any of the pump stations, and from any one of the pump stations to any of the refineries, and Texxon is looking for a minimum cost schedule. The refineries' requirements are as follows.

| Refinery | R1 | R2 | R3 | R4 | R5 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Requirement (TBD) | 30 | 57 | 48 | 91 | 48 |

The company's cost accounting system recognizes charges by the segment of pipeline that is used. These daily costs are given in the tables below, in dollars per thou- sand barrels.

| To | | Pump A | Pump B | Pump C |
|---|---|---|---|---|
| From | Well 1 | 1.52 | 1.60 | 1.40 |
| | Well 2 | 1.70 | 1.63 | 1.55 |
| | Well 3 | 1.45 | 1.57 | 1.30 |

| To | | R1 | R2 | R3 | R4 | R5 |
|---|---|---|---|---|---|---|
| From | Pump A | 5.15 | 5.69 | 6.13 | 5.63 | 5.80 |
| | Pump B | 5.12 | 5.47 | 6.05 | 6.12 | 5.71 |
| | Pump C | 5.32 | 6.16 | 6.25 | 6.17 | 5.87 |

1) What is the minimum cost of providing oil to the refineries? Which wells are used to capacity in the optimal schedule? Formulation of the problem is enough.
2) Show the network diagram corresponding to the solution in (a). That is, label each of the arcs in the solution and verify that the flows are consistent with the given information.
3)

## Learning Outcomes

The assignment will help you formulate and solve a transportation and transshipment problem.

## Requirements

All assignments are due before the next class.

## General Submission Instructions

*All work must be your own. Copying other people's work or from the Internet is a form of plagiarism and will be prosecuted as such.*

1. Upload an R markdown file, along with any required .lp files to your git repository. Name your file Username_#.ext, where Username is your Kent State User ID (the part before @), and # is the Assignment number.
2. Note that the R markdown file allows you to add text, comments, and output as part of the file. So, all documentation should be part of the file. You can read about the R markdown file syntax here, or download the cheat sheet directly.

Provide the link to your git repository in Blackboard Learn for the assignment.

# Solution

Q1)

**1.1 Decision Variables: XIJ, where I = Plant (A, B) & J = Warehouse (1, 2, 3)**

PLANT A TO WAREHOUSE 1: XA1
PLANT A TO WAREHOUSE 2: XA2
PLANT A TO WAREHOUSE 3: XA3
PLANT B TO WAREHOUSE 1: XB1
PLANT B TO WAREHOUSE 2: XB2
PLANT B TO WAREHOUSE 3: XB3
DUMMY VARIABLE: XD

**1.2 Objective Function:**

MINIMUM Z = 622XA1 + 614XA2 + 630 XA3 + 641 XB1 + 645 XB2 + 649 XB3 + 0 (XAD + XBD)

**1.3 Subject to:**

XA1 + XA2 + XA3 + XAD = 100
XB1 + XB2 + XB3 + XBD = 120
XA1 + XB1 = 80
XA2 + XB2 = 60
XA3 + XB3 = 70
XAD + XBD = 10

Also, all XIJ ≥ 0.

**Note: See file dpetwal_4.R & dpetwal_4.lp**

Q2) 1

**2.1 Decision Variables: XIJ & XJK, where I = Well (1, 2, 3), J = Pump (A, B, C) & K = Refinery (1, 2, 3, 4, 5, 6)**

WELL 1 TO PUMP A: X1A
WELL 1 TO PUMP B: X1B
WELL 1 TO PUMP C: X1C
WELL 2 TO PUMP A: X2A
WELL 2 TO PUMP B: X2B
WELL 2 TO PUMP C: X2C
WELL 3 TO PUMP A: X3A
WELL 3 TO PUMP B: X3B
WELL 3 TO PUMP C: X3C

PUMP A TO REFINERY 1: XA1
PUMP B TO REFINERY 1: XB1
PUMP C TO REFINERY 1: XC1
PUMP A TO REFINERY 2: XA2
PUMP B TO REFINERY 2: XB2
PUMP C TO REFINERY 2: XC2
PUMP A TO REFINERY 3: XA3
PUMP B TO REFINERY 3: XB3
PUMP C TO REFINERY 3: XC3
PUMP A TO REFINERY 4: XA4
PUMP B TO REFINERY 4: XB4
PUMP C TO REFINERY 4: XC4
PUMP A TO REFINERY 5: XA5
PUMP B TO REFINERY 5: XB5
PUMP C TO REFINERY 5: XC5
DUMMY REFINERY 6

**2.2 Objective Function:**

MINIMUM Z = 1.52 X1A + 1.70 X2A + 1.45 X3A + 1.60 X1B + 1.63 X2B + 1.57 X3B + 1.40 X1C + 1.55 X2C + 1.30 X3C + 5.15 XA1 + 5.12 XB1 + 5.32 XC1 + 5.69 XA2 + 5.47 XB2 + 6.16 XC2 + 6.13 XA3 + 6.05 XB3 + 6.25 XC3 + 5.63 XA4 + 6.12 XB4 + 6.17 XC4 + 5.80 XA5 + 5.71 XB5 + 5.87 XC5 + 0 (XA6 + XB6 + XC6)

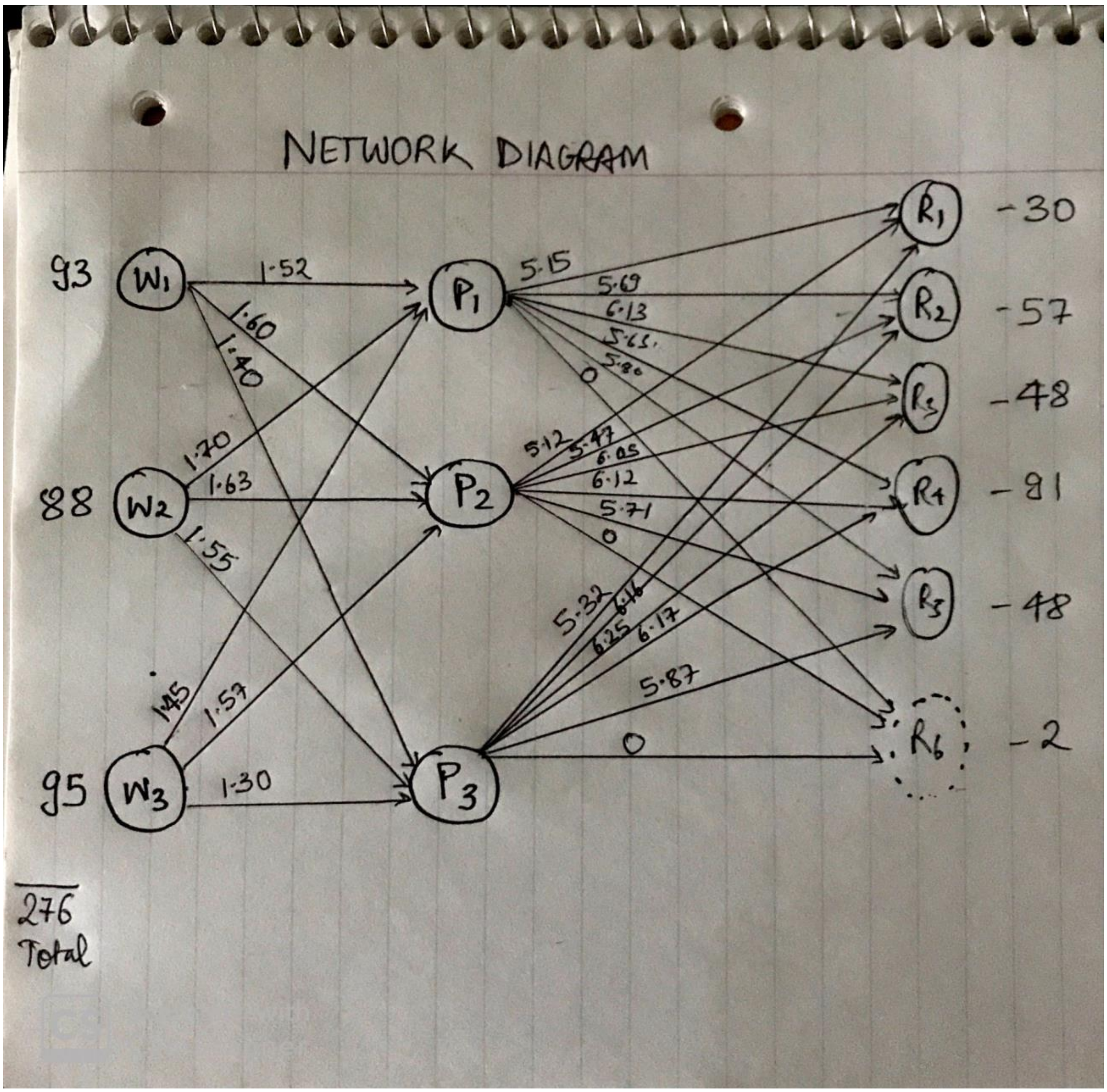
**2.2 Subject to:**

$$X1A + X1B + X1C = 93$$
$$X2A + X2B + X2C = 88$$
$$X3A + X3B + X3C = 95$$
$$XA1 + XB1 + XC1 = 30$$
$$XA2 + XB2 + XC2 = 57$$
$$XA3 + XB3 + XC3 = 48$$
$$XA4 + XB4 + XC4 = 91$$
$$XA5 + XB5 + XC5 = 48$$
$$XA6 + XB6 + XC6 = 2$$

$$X1A + X2A + X3A = XA1 + XA2 + XA3 + XA4 + XA5 + XA6$$
$$X1B + X2B + X3B = XB1 + XB2 + XB3 + XB4 + XB5 + XB6$$
$$X1C + X2C + X3C = XC1 + XC2 + XC3 + XC4 + XC5 + XC6$$

Also, for all $XIJ \geq 0$ & $XJK \geq 0$

Q2) 2


NETWORK DIAGRAM
93
88
95
W1
W2
W3
P1
P2
P3
R1
R2
R3
R4
R5
R6
-30
-57
-48
-91
-48
-2
1.52
1.60
1.40
1.70
1.63
1.55
1.45
1.57
1.30
5.15
5.69
6.13
5.63
5.80
0
5.12
5.47
6.05
6.12
5.71
0
5.32
6.16
6.25
6.17
5.87
0
276
Total