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2) Please remove your hat. If it is part of your head, turn it around backwards.

3) If your work is not legible, or if I cannot follow your logic at a glance, it will receive no credit. This paper must be written to acceptable engineering standards for credit. Please take this seriously as it will affect your grade.

4) You may work on the front or back of this paper. Just note if work is on the back.

5) You can use your own paper or paper supplied at the front of the room.

6) You MUST specify what you are doing every step of the way. ONLY if I can follow what you are trying to do and where you are getting your numbers from, will you receive partial credit should you go off track.

7) Write big and use lots of paper, leaving me room to grade your paper. If there is no room to tell you why points were deducted, I will only show you the point deduction and let you try and figure out why.

I have read and understand all of the above instructions: ____________ (Initials)

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"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this exam."

________________________
Signature of student

Please do not open this exam until you are told to do so.
Problem 1) Our company makes tables and chairs. Material cost for each table is $500, and $100 for each chair. Tables sell for $1200 each, and chairs for $400 each. The company has 20 workers who can each work on this project for up to 160 hours per month, although if not needed here we can shift them to other projects. Workers cost $30/hour, including wages and all benefits. It takes six hours to make a table and three hours to make a chair. At the beginning of the month we borrow the money required to pay the workers for the coming month, and to buy the materials required for the coming month’s production. For the coming month we can borrow up to $160,000. Customer demand requires that we make at least four times as many chairs as tables, but not more than 10 chairs per table. Back orders from last month require us to make no fewer than 10 tables or fewer than 4 chairs. Tables take 200 ft^3 of storage space and chairs take 40 ft^3 and all must be stored until the end of the month, at which time they are sold. We currently have up to 40,000 ft^3 of storage space available.

Formulate this problem as a linear programming problem.
\[ T = \# \text{ of tables} \quad \text{IF} \quad \text{FIFIMBEI to make} \]
\[ c = \text{ chairs} \]

\[ \text{Max } Z = \left( \frac{1200}{\text{Table}} - \frac{30}{\text{hour}} \times \frac{6 \text{ hours}}{\text{Table}} - \frac{500}{\text{Table}} \right) T \]
\[ + \left( \frac{400}{\text{chain}} - \frac{30}{\text{hour}} \times \frac{3 \text{ hours}}{\text{chain}} - \frac{100}{\text{chain}} \right) C \]

\[ \text{Max Profit} \]

\[ \text{Max} \left\{ \left( \frac{6 \text{ hours}}{\text{Table}} \times \frac{30}{\text{hour}} + \frac{500}{\text{Table}} \right) T \right\} \]
\[ + \left( 3 \times 30 + 100 \right) C \leq 169,000 \]

\[ \text{Available} \]
\[ \begin{cases} 4T \leq C & 4 \text{ chains} \quad T \leq 4 \\ 4T - C \leq 0 & \text{ portable} \quad T \leq 6 \end{cases} \]

\[ \text{OK} \]

\[ 200 \text{ ft}^3 \times T + 40C \leq 40,000 \text{ ft}^3 \quad \text{Space} \]

\[ 6 \text{ hours} \times T + 3C \leq 168 \times \frac{\text{ft}^3}{\text{worker}} \]
MOR/LP

Date: 11/4/14

V:\tables.txt

Time: 19:26:24

MODEL DESCRIPTION

Max Z = (1200 - 30*6 - 500)*T + (400 - 30*3 - 100)*C

ST

(6*30+500)*T + (3*30 + 100)*C <= 16000  "Money limit"
4T - C <= 0  "At least 4 chairs per table"
10T - C >= 0  "No more than 10 chairs per table"
T >= 10  "Minimum 200 tables"
C >= 4  "Minimum 400 chairs"
200T + 40C <= 4000  "Storage limit"
6T + 3C <= 3200  "Maximum worker time"

"Allinteger"

Boundonsum = 1000"

"Run under Gomery Cut Method"

^^^^ Optimal Solution ^^^

Z = 15368.4208
T = 10.0000
C = 48.4211
Slack2 = 8.4211
Surpl3 = 51.5789
Surpl5 = 44.4211
Slack6 = 63.1579
Slack7 = 2994.7368

Compile time: 0.33 (Secs.)
Run time : 0.05 (Secs.)
Problem 2) I have a $200,000 20 year 5.25% mortgage on my home that I took out several years ago. I am taking my 100th monthly check to the bank as we speak. How much of this check will go towards interest, and how much will be applied to reduction of principal?
Payment on $200,000 5.25% 20yr

\[ A = 200,000 \left[ \frac{A}{P}, \frac{0.0525}{12}, 20+12 \right] \]

\[ = 200,000 \left[ 0.0067384 \right] \]

\[ = 1347.68 \]

\[ F = 1347.68 \]

\[ 200,000 \]

\[ -200,000 + 1347.68 \left[ \frac{P}{A}, \frac{0.0525}{12}, 99 \right] + F \left[ \frac{P}{F}, \frac{0.0525}{12}, 99 \right] = 0 \]

\[ F = \frac{200,000 - 1347.68 \left( 80.207454 \right)}{0.6490923} \]

\[ = 141,591.45 \]

So interest on the value of a $141,591.45 loan for one month @ 0.0525/12

\[ = \frac{141,591.45 \times 0.0525}{12} = 619.42 \]

Payment = $1347.68
Principal = $1347.68 - $619.42
Problem 3) Our company has been tasked to optimize the contents of a plane load of personnel and equipment to be flown to Libya. The specs are listed below, including what may be loaded, lives saved per unit carried, etc. Our budget is limited to $500,000. Set up the L.P. solution for what should be taken. The plane has a total volume capacity of 40,000 cubic feet, of which 1500 ft^3 is air conditioned and pressurized, and a separate volume of 3000 ft^3 is pressurized only. Maximum payload of the craft is 100,000 pounds.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Volume (ft^3)</th>
<th>Weight (lbs)</th>
<th>Cost ($)</th>
<th>Space Required</th>
<th>Minimum Number</th>
<th>Maximum Number</th>
<th>Lives Saved per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctors</td>
<td>50</td>
<td>500</td>
<td>5000</td>
<td>AC/Pressurized</td>
<td>3</td>
<td>8</td>
<td>400</td>
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<tr>
<td>Nurses</td>
<td>45</td>
<td>300</td>
<td>3000</td>
<td>AC/Pressurized</td>
<td>2 per doctor</td>
<td>-</td>
<td>2000</td>
</tr>
<tr>
<td>Field tents</td>
<td>2500</td>
<td>1200</td>
<td>50000</td>
<td></td>
<td>1</td>
<td>3</td>
<td>10000</td>
</tr>
<tr>
<td>Beds</td>
<td>6</td>
<td>40</td>
<td>100</td>
<td></td>
<td>50</td>
<td>300</td>
<td>10</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.13</td>
<td>9</td>
<td>3</td>
<td>Pressurized</td>
<td>1000</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>1</td>
<td>5</td>
<td>1000</td>
<td>Pressurized</td>
<td>100</td>
<td>5000</td>
<td>20</td>
</tr>
<tr>
<td>Generators</td>
<td>20</td>
<td>1000</td>
<td>20000</td>
<td></td>
<td>-</td>
<td>-</td>
<td>1000</td>
</tr>
</tbody>
</table>
MOR/LP

Date: 11/15/14
Time: 39:07:32

Y:\eubola.txt

MODEL DESCRIPTION

Max Z = 400D + 2200N + 10000F + 10B + 2C + 20A + 1000G

ST

50D + 45N <= 1500 "LIMIT ON AC/PRESSURIZED VOLUME"
50D + 45N + 0.13C + 1A <= 4500 "1500 + 3000 LIMIT ON PRESSURIZED VOLUME"
50D + 45N + 2500F + 6B + 0.13C + 1A + 20G <= 40000 "LIMIT ON TOTAL VOLUME"
500D + 300N + 1200F + 40B + 9C + 5A + 1000G <= 100000 "WEIGHT LIMIT"
5000D + 3000N + 50000F + 100B + 3C + 1000A + 20000G <= 500000 "BUDGET"

D >= 3 "AT LEAST 3 DOCTORS"
D <= 8 "NO MORE THAN 8 DOCTORS"
2D - N <= 0 "AT LEAST 2 NURSES FOR EACH DOCTOR"
F >= 1 "AT LEAST ONE FIELD TENT"
F <= 3 "AT LEAST ONE FIELD TENTS"
B >= 50 "AT LEAST 50 BEDS"
B <= 300 "NO MORE THAN 300 BEDS"
C >= 1000 "AT LEAST 1000 GALLONS CHLORINE"
A >= 100 "AT LEAST 100 ANTIBIOTICS"
A <= 5000 "NO MORE THAN 5000 ANTIBIOTICS"

"FOR CHECKING SOLUTION ONLY - NOT REQUIRED IN MODEL"

"Volumes"
50D - DVOLUME = 0 "CALCULATE FINAL DOCTOR VOLUME"
45N - NVOLUME = 0 "ETC."
2500F - FVOLUME = 0
6B - BVOLUME = 0
0.13C - CVOLUME = 0
1A - AVOLUME = 0
20G - GVOLUME = 0
50D + 45N - DVOLUME = 0 "CALCULATE FINAL DOCTOR + NURSE VOLUME"
50D + 45N + 0.13C + 1A - DNCAVOLUME = 0 "FINAL DOCTOR + NURSE + CHLORINE + ANTIBIOTICS VOLUME"
50D + 45N + 2500F + 6B + 0.13C + 1A + 20G - TOTALVOLUME = 0 "FINAL TOTAL VOLUME USED ON TRIP"

"Weights"
500D - DWEIGHT = 0 "CALCULATE FINAL DOCTOR WEIGHT"
300N - NWEIGHT = 0 "ETC."
1200F - FWEIGHT = 0
40B - BWEIGHT = 0
9C - CWEIGHT = 0
5A - AWEIGHT = 0
1000G - GWEIGHT = 0
5000D + 300N + 1200F + 40B + 9C + 5A + 1000G - TOTALWEIGHT = 0

"Costs"
400D + 2200N + 10000F + 10B + 2C + 20A + 1000G - TOTALCOST = 0

"Allinteger - Note that to actually run a problem this complex and get integer
values would require much more time and computing power than a desktop PC. The solution below uses the Simplex method and still gets a lot of integers.
Boundonsum = 1000
Run under Gomery Cut Method"

"Why is 50D + 45N + 0.13C + 1A <= 1500 wrong? Because say that C and A both gave lives saved = 30,000 each, and you decided to take no Doctors and no Nurses (assume D >= 3 was not required). Then you just restricted 0.13C + 1A <= 1500, rather than 4500!"

Simplex Method

^^^^ Optimal Solution ^^^

Z = 116579.2537
D = 3.0000
N = 30.0000
F = 3.0000
B = 50.0000
C = 8632.7684
A = 100.0000
G = 5.7051
DVOLUME = 150.0000
NVOLUME = 1350.0000
FVOLUME = 7500.0000
B VOLUME = 300.0000
CVOLUME = 1122.2599
AVOLUME = 100.0000
GVOLUME = 114.1017
DNVOLUME = 1500.0000
DNCAVOLUME = 2722.2599
TOTALVOLUME = 10636.3616
DWEIGHT = 1500.0000
NWEIGHT = 9000.0000
FWEIGHT = 3600.0000
BWEIGHT = 2000.0000
CWEIGHT = 77694.9153
AWEIGHT = 500.0000
GWEIGHT = 5795.0847
TOTALWEIGHT = 100000.0000
TOTALCOST = 116670.6215
Slack2 = 1777.7401
Slack3 = 29363.6384
Slack7 = 5.0000
Slack8 = 24.0000
Surpl9 = 2.0000
Slack12 = 250.0000
Surpl13 = 7632.7684
Slack15 = 4900.0000

Compile time: 1.43 (Secs.)
I am a graduating senior—circle one: Yes—No

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<td>40</td>
<td>500</td>
<td>6000</td>
<td>AC/Pressurized</td>
<td>4</td>
<td>108</td>
<td>800</td>
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<tr>
<td>Nurses</td>
<td>35</td>
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<td>Generators</td>
<td>30</td>
<td>1000</td>
<td>15000</td>
<td></td>
<td>-</td>
<td>-</td>
<td>2000</td>
</tr>
</tbody>
</table>
Max Z = 800D + 3000N + 1000F + 20B + 4C + 30A + 2000G

ST

40D + 35N <= 3500 "LIMIT ON AC/PRESSURIZED VOLUME"

40D + 35N + 0.13C + 1A <= 11500 "3500 + 8000 LIMIT ON PRESSURIZED VOLUME"

40D + 35N + 1500F + 10B + 0.13C + 2A + 30G <= 30000 "LIMIT ON TOTAL VOLUME"

500D + 300N + 1200F + 40B + 9C + 5A + 100G <= 70000 "WEIGHT LIMIT"

6000D + 4000N + 30000F + 1100B + 13C + 600A + 1500G <= 800000 "BUDGET"

D >= 4 "AT LEAST 4 DOCTORS"

D <= 108 "NO MORE THAN 108 DOCTORS"

3D - N <= 0 "AT LEAST 3 NURSES FOR EACH DOCTOR"

F >= 3 "AT LEAST 3 FIELD TENTS"

F <= 5 "NO MORE THAN 5 FIELD TENTS"

B >= 80 "AT LEAST 80 BEDS"

B <= 300 "NO MORE THAN 300 BEDS"

C >= 1000 "AT LEAST 1000 GALLONS CHLORINE"

A >= 200 "AT LEAST 200 ANTIBIOTICS"

A <= 5000 "NO MORE THAN 5000 ANTIBIOTICS"
2) Several years ago I took out a $300,000 30 year 4.75% mortgage on my home. I am taking my 80\textsuperscript{th} monthly check to the bank as we speak. How much of this check will go towards interest, and how much will be applied to reduction of principal?
Payment on $300,000 at 4.75% for 30 years.

\[
0.0475/12 = 0.00395833\% / \text{month}
\]

\[
m = 30 * 12 = 360
\]

\[-300,000 + A \left[ \frac{P}{A}, 0.003958, 360 \right] = 0
\]

\[A = \frac{191,700.3941}{191,700.3941} = 1564.94 / \text{month}
\]

\[
F = 300,000 - 1564.94 \left[ \frac{P}{A}, 0.003958, 79 \right] + F \left[ \frac{P}{F}, 0.003958, 79 \right] = 0
\]

\[F = \frac{300,000 - 105,988}{0.7319149} = 265,074
\]

\[265,074 \times 0.0475 / 12 = 1049.25 \text{ interest}
\]

\[515.69 \text{ principal}
\]
Problem 3) Our company makes wheels and hubs for large earthmoving equipment. It takes eight hours to make a wheel and two hours to make a hub. Customer demand requires that we make at least eight times as many hubs as wheels, but not more than 20 hubs per wheel. Back orders from last month require us to make no fewer than 8 wheels or fewer than 2 hubs. Wheels take 20 ft$^3$ of storage space and hubs take 4 ft$^3$ and all must be stored until the end of the month, at which time they are sold. We currently have up to 4,000 ft$^3$ of storage space available. At the beginning of the month we borrow the money required to pay the workers for the coming month, and to buy the materials required for the coming month’s production. For the coming month we can borrow up to $260,000. Material cost for each wheel is $1,500, and $1,000 for each hub. Wheels sell for $3,200 each, and hubs for $1,400 each. Workers cost $40/hour, including wages and all benefits. The company has 60 workers who can each work on this project for up to 140 hours per month, although if not needed here we can shift them to other projects.

Formulate this problem as a linear programming problem.

$$\text{Maximize } Z = \text{Wheel}(8 \text{ hours} \cdot \frac{3,200}{\text{hours}}) - \frac{1500}{\text{wheel}} + \text{Hub}(2 \text{ hours} \cdot \frac{1,400}{\text{hour}}) = 1380w + 320H$$

Constraints:

1. Customer demands:
   \[
   \frac{H}{W} \geq 8 \quad \frac{H}{W} \leq 20
   \]

2. Back orders:
   \[
   W \geq 8, \quad H \geq 2
   \]

3. Storage:
   \[
   20W + 4H \leq 4,000 \text{ ft}^3
   \]

4. Labor limits:
   \[
   1500W + 1000H + 8 \text{ hours/week} \cdot \frac{40 \text{ $/hour}}{W} + 2 \text{ hours/day} \cdot \frac{40 \text{ $/hour}}{H} \leq 260,000
   \]

   \[
   1820W + 1080H \leq 2,600,000
   \]

5. Workers/months:
   \[
   60 \text{ workers} \times 140 \text{ hours} = 8,400 \text{ man hours}
   \]

   \[
   8W + 2H \leq 8,400 \text{ man hours}
   \]