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Airport Systems Modelling and Simulation Assignment 5

Q1

z = 189

Flight ID	Time Allocated										Maximum Displacement	Total Displacement	Allocated ?
	1	2	3	4	5	6	7	8	9	10			
1	0	0	0	1	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	1	0	0	0	0	1	6	1
3	0	0	0	0	1	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	0	1	0	3	15	1
5	0	0	0	0	0	0	0	1	0	0	2	10	1
6	0	0	0	0	0	0	0	1	0	0	1	5	1
7	0	1	0	0	0	0	0	0	0	0	2	12	1
8	0	0	0	0	0	1	0	0	0	0	1	6	1
9	0	0	0	0	0	0	0	0	1	0	3	15	1
10	0	0	0	0	0	0	0	0	0	1	3	12	1
11	0	0	1	0	0	0	0	0	0	0	1	8	1
12	0	0	1	0	0	0	0	0	0	0	0	0	1
13	0	0	0	0	1	0	0	0	0	0	1	7	1
14	0	1	0	0	0	0	0	0	0	0	3	18	1
15	0	0	0	0	0	0	0	0	0	1	4	16	1
16	0	0	0	1	0	0	0	0	0	0	0	0	1
17	1	0	0	0	0	0	0	0	0	0	5	15	1
18	1	0	0	0	0	0	0	0	0	0	5	20	1
19	0	0	0	0	0	0	1	0	0	0	2	12	1
20	0	0	0	0	0	0	1	0	0	0	2	12	1
												189	
Scheduled Flights	1	2	3	4	5	6	7	8	9	10			
Day 1	0	2	2	2	2	1	1	0	1	1			
Day 2	1	1	2	2	0	2	1	2	1	0			
Day 3	0	0	1	2	1	2	2	0	2	1			
Day 4	1	2	1	2	1	0	1	2	0	0			
Day 5	2	0	1	2	2	0	1	1	1	2			
Day 6	2	2	2	2	2	2	1	1	1	0			
Day 7	0	2	1	2	1	2	1	1	2	0			
Day 8	0	0	2	2	1	1	2	2	0	1			
Day 9	1	2	1	2	2	1	1	0	2	1			
Day 10	0	1	1	2	2	1	1	1	0	2			

Q2

z = 106

AMPL IDE

File Edit Commands Window Help

Current Directory: C:\Users\1004666\Downloads\WOLTL\AMPL_Ex3_SlotAllocation

Assignment_3_2.mod Assignment_3_2.run Assignment_3_2.dat

subject to C2[10,2]:
 $V[1,10] + V[2,10] + V[5,10] + V[6,10] + V[8,10] + V[9,10] + V[11,10] + V[12,10] + V[14,10] + V[16,10] + V[18,10] + V[20,10] \leq 2;$

subject to C2[10,3]:
 $V[1,10] + V[2,10] + V[3,10] + V[4,10] + V[8,10] + V[9,10] + V[12,10] + V[15,10] + V[16,10] + V[19,10] + V[20,10] \leq 2;$

subject to C2[10,4]:
 $V[1,10] + V[3,10] + V[5,10] + V[6,10] + V[7,10] + V[11,10] + V[14,10] + V[15,10] + V[17,10] + V[20,10] \leq 2;$

subject to C2[10,5]:
 $V[1,10] + V[3,10] + V[4,10] + V[5,10] + V[10,10] + V[11,10] + V[15,10] + V[16,10] + V[17,10] + V[18,10] + V[19,10] \leq 2;$

subject to C2[10,6]:
 $V[1,10] + V[2,10] + V[3,10] + V[4,10] + V[6,10] + V[7,10] + V[8,10] + V[9,10] + V[11,10] + V[12,10] + V[13,10] + V[14,10] + V[16,10] + V[17,10] + V[18,10] + V[19,10] \leq 2;$

subject to C2[10,7]:
 $V[1,10] + V[2,10] + V[4,10] + V[5,10] + V[7,10] + V[8,10] + V[9,10] + V[12,10] + V[13,10] + V[14,10] + V[16,10] + V[18,10] + V[20,10] \leq 2;$

subject to C2[10,8]:
 $V[1,10] + V[2,10] + V[5,10] + V[6,10] + V[11,10] + V[12,10] + V[13,10] + V[15,10] + V[16,10] + V[19,10] + V[20,10] \leq 2;$

subject to C2[10,9]:
 $V[1,10] + V[3,10] + V[4,10] + V[7,10] + V[8,10] + V[9,10] + V[10,10] + V[11,10] + V[14,10] + V[16,10] + V[18,10] + V[20,10] \leq 2;$

subject to C2[10,10]:
 $V[1,10] + V[3,10] + V[6,10] + V[7,10] + V[8,10] + V[10,10] + V[11,10] + V[13,10] + V[15,10] + V[16,10] + V[19,10] \leq 2;$

CPLEX 20.1.0.0: optimal integer solution; objective 106
233 MIP simplex iterations
0 branch-and-bound nodes

V["*"]
1 1 2 2 4 5 6 7 8 9 10
1 0 0 0 1 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 1 0 0 0 0
4 0 0 0 0 0 0 1 0 0 0
5 0 0 0 0 0 0 0 0 0 0
6 0 0 0 0 0 0 1 0 0 0
7 0 1 0 0 0 0 0 0 0 0
8 0 0 0 0 0 1 0 0 0 0
9 0 0 0 0 0 0 0 1 0 0
10 0 0 0 0 0 0 0 0 1 0
11 0 1 0 0 0 0 0 0 0 0
12 0 0 1 0 0 0 0 0 0 0
13 0 0 1 0 0 0 0 0 0 0
14 0 0 0 0 1 0 0 0 0 0
15 0 0 0 0 0 0 1 0 0 0
16 0 0 0 1 0 0 0 0 0 0
17 0 0 0 0 0 0 0 0 1 0
18 0 0 0 0 0 0 0 1 0 0
19 0 0 0 0 1 0 0 0 0 0
20 0 0 0 0 0 1 0 0 0 0

z = 106
ampl:
<

Flight ID \ Time Requested (Displacement Cost)
param nf := 20;
param nt := 10;
param nd := 10;

Flight ID \ Day (Days)
param d0: 1 2 3 4 5 6 7 8 9 10:=
1 1 1 1 1 1 1 1 1 1
2 1 1 1 0 1 1 1 0 0
3 1 0 1 1 1 1 0 0 0
4 1 0 1 0 1 0 1 0 1
5 0 1 0 1 1 0 1 1 0
6 0 1 0 1 0 1 0 1 0
7 1 0 0 1 0 1 1 0 1
8 0 1 1 0 0 1 1 0 1
9 0 1 1 0 0 1 0 1 0
10 1 0 0 0 1 0 0 0 1
11 1 1 0 0 0 1 1 1 1
12 1 1 0 0 0 1 1 1 0
13 1 0 0 0 1 1 1 1 1
14 1 0 0 0 1 0 1 1 0
15 0 0 1 0 1 0 0 1 0
16 1 0 0 0 1 1 1 1 1
17 0 0 0 0 1 1 1 0 0
18 0 1 0 0 1 1 0 0 1
19 1 0 1 0 1 0 1 0 1
20 0 1 1 1 0 0 1 1 0

Day \ Time Allocated (Capacity)
param c0: 1 2 3 4 5 6 7 8 9 10:=
1 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2
3 2 2 2 2 2 2 2 2 2
4 2 2 2 2 2 2 2 2 2
5 2 2 2 2 2 2 2 2 2
6 2 2 2 2 2 2 2 2 2
7 2 2 2 2 2 2 2 2 2
8 2 2 2 2 2 2 2 2 2
9 2 2 2 2 2 2 2 2 2
10 2 2 2 2 2 2 2 2 2

Q3
 $z = 109$

```
subject to C3[12]:
2**[12,1] + Y[12,2] + Y[12,4] + 2**[12,5] + 3**[12,6] + 4**[12,7] +
5**[12,8] + 6**[12,9] + 7**[12,10] <= 2;

subject to C3[13]:
3**[13,1] + 2**[13,2] + Y[13,3] + Y[13,5] + 2**[13,6] + 3**[13,7] +
4**[13,8] + 5**[13,9] + 6**[13,10] <= 2;

subject to C3[14]:
4**[14,1] + 3**[14,2] + 2**[14,3] + Y[14,4] + Y[14,6] + 2**[14,7] +
3**[14,8] + 4**[14,9] + 5**[14,10] <= 2;

subject to C3[15]:
5**[15,1] + 4**[15,2] + 3**[15,3] + 2**[15,4] + Y[15,5] + Y[15,7] +
2**[15,8] + 3**[15,9] + 4**[15,10] <= 2;

subject to C3[16]:
3**[16,1] + 2**[16,2] + Y[16,3] + Y[16,5] + 2**[16,6] + 3**[16,7] +
4**[16,8] + 5**[16,9] + 6**[16,10] <= 2;

subject to C3[17]:
5**[17,1] + 4**[17,2] + 3**[17,3] + 2**[17,4] + Y[17,5] + Y[17,7] +
2**[17,8] + 3**[17,9] + 4**[17,10] <= 2;

subject to C3[18]:
5**[18,1] + 4**[18,2] + 3**[18,3] + 2**[18,4] + Y[18,5] + Y[18,7] +
2**[18,8] + 3**[18,9] + 4**[18,10] <= 2;

subject to C3[19]:
4**[19,1] + 3**[19,2] + 2**[19,3] + Y[19,4] + Y[19,6] + 2**[19,7] +
3**[19,8] + 4**[19,9] + 5**[19,10] <= 2;

subject to C3[20]:
4**[20,1] + 3**[20,2] + 2**[20,3] + Y[20,4] + Y[20,6] + 2**[20,7] +
3**[20,8] + 4**[20,9] + 5**[20,10] <= 2;

CPLEX 20.1.0.0: optimal integer solution; objective 109
123 HDP simplex iterations
0 branch-and-bound nodes
Y [*,""]
: 1 2 3 4 5 6 7 8 9 10 :=
1 0 0 0 1 0 0 0 0 0
2 0 0 0 0 0 1 0 0 0
3 0 0 0 0 0 1 0 0 0
4 0 0 0 0 0 0 1 0 0
5 0 0 0 0 0 1 0 0 0
6 0 0 0 0 0 0 0 1 0
7 0 1 0 0 0 0 0 0 0
8 0 0 0 0 0 1 0 0 0
9 0 0 0 0 0 0 0 1 0
10 0 0 0 0 0 0 0 0 1
11 0 1 0 0 0 0 0 0 0
12 0 0 0 0 0 0 0 0 0
13 0 1 0 0 0 0 0 0 0
14 0 0 0 1 0 0 0 0 0
15 0 0 0 0 0 0 1 0 0
16 0 0 1 0 0 0 0 0 0
17 0 0 0 0 0 0 0 1 0
18 0 0 0 0 0 0 1 0 0
19 0 0 0 1 0 0 0 0 0
20 0 0 0 0 1 0 0 0 0
z = 109
AMPL:
```

Q4
Max displacement = 1 → problem infeasible

```
subject to C3[12]:
2**[12,1] + Y[12,2] + Y[12,4] + 2**[12,5] + 3**[12,6] + 4**[12,7] +
5**[12,8] + 6**[12,9] + 7**[12,10] <= 1;

subject to C3[13]:
3**[13,1] + 2**[13,2] + Y[13,3] + Y[13,5] + 2**[13,6] + 3**[13,7] +
4**[13,8] + 5**[13,9] + 6**[13,10] <= 1;

subject to C3[14]:
4**[14,1] + 3**[14,2] + 2**[14,3] + Y[14,4] + Y[14,6] + 2**[14,7] +
3**[14,8] + 4**[14,9] + 5**[14,10] <= 1;

subject to C3[15]:
5**[15,1] + 4**[15,2] + 3**[15,3] + 2**[15,4] + Y[15,5] + Y[15,7] +
2**[15,8] + 3**[15,9] + 4**[15,10] <= 1;

subject to C3[16]:
3**[16,1] + 2**[16,2] + Y[16,3] + Y[16,5] + 2**[16,6] + 3**[16,7] +
4**[16,8] + 5**[16,9] + 6**[16,10] <= 1;

subject to C3[17]:
5**[17,1] + 4**[17,2] + 3**[17,3] + 2**[17,4] + Y[17,5] + Y[17,7] +
2**[17,8] + 3**[17,9] + 4**[17,10] <= 1;

subject to C3[18]:
5**[18,1] + 4**[18,2] + 3**[18,3] + 2**[18,4] + Y[18,5] + Y[18,7] +
2**[18,8] + 3**[18,9] + 4**[18,10] <= 1;

subject to C3[19]:
4**[19,1] + 3**[19,2] + 2**[19,3] + Y[19,4] + Y[19,6] + 2**[19,7] +
3**[19,8] + 4**[19,9] + 5**[19,10] <= 1;

subject to C3[20]:
4**[20,1] + 3**[20,2] + 2**[20,3] + Y[20,4] + Y[20,6] + 2**[20,7] +
3**[20,8] + 4**[20,9] + 5**[20,10] <= 1;

CPLEX 20.1.0.0: Infeasible.
13 HDP simplex iterations
0 branch-and-bound nodes
No basis.
Y [*,""]
: 1 2 3 4 5 6 7 8 9 10 :=
1 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 0 0 0 0
3 0 0 0 0 0 0 0 0 0
4 0 0 0 0 0 0 0 0 0
5 0 0 0 0 0 0 0 0 0
6 0 0 0 0 0 0 0 0 0
7 0 0 0 0 0 0 0 0 0
8 0 0 0 0 0 0 0 0 0
9 0 0 0 0 0 0 0 0 0
10 0 0 0 0 0 0 0 0 0
11 0 0 0 0 0 0 0 0 0
12 0 0 0 0 0 0 0 0 0
13 0 0 0 0 0 0 0 0 0
14 0 0 0 0 0 0 0 0 0
15 0 0 0 0 0 0 0 0 0
16 0 0 0 0 0 0 0 0 0
17 0 0 0 0 0 0 0 0 0
18 0 0 0 0 0 0 0 0 0
19 0 0 0 0 0 0 0 0 0
20 0 0 0 0 0 0 0 0 0
z = 0
AMPL:
```

After adding Ri as a variable and included in the objective function and constraints, 3 flights rejected (1, 3, 16) and total slot displacement = 65 (3065 (new obj fx) – 3 flights rejected * 1000).

The screenshot shows the AMPL IDE interface with the following components:

- File Explorer (Left):** Lists files in the current directory, including Assignment_5_2.dat, Assignment_5_2.mod, Assignment_5_2.run, Assignment_5_3.dat, Assignment_5_3.mod, Assignment_5_3.run, Assignment_5_4.dat, Assignment_5_4.mod, Assignment_5_4.run, ExampleSlotAllocation.dat, ExampleSlotAllocation.mod, and ExampleSlotAllocation.run.
- Console (Middle):** Displays the AMPL model code and the CPLEX solver output.


```

AMPL
2*y[17,8] + 3*y[17,9] + 4*y[17,10] <= 1;

subject to C3[18]:
5*y[18,1] + 4*y[18,2] + 3*y[18,3] + 2*y[18,4] + y[18,5] + y[18,7] +
3*y[18,8] + 3*y[18,9] + 4*y[18,10] <= 1;

subject to C3[19]:
4*y[19,1] + 3*y[19,2] + 2*y[19,3] + y[19,4] + y[19,6] + 2*y[19,7] +
3*y[19,8] + 4*y[19,9] + 5*y[19,10] <= 1;

subject to C3[20]:
4*y[20,1] + 3*y[20,2] + 2*y[20,3] + y[20,4] + y[20,6] + 2*y[20,7] +
3*y[20,8] + 4*y[20,9] + 5*y[20,10] <= 1;

CPLEX 28.1.0.8: optimal integer solution; objective 3065
93 NLP simplex iterations
0 branch-and-bound nodes
v[*] :=
1 1 2 3 4 5 6 7 8 9 10 :=
1 0 0 0 0 0 0 0 0 0 0
2 0 0 0 0 0 1 0 0 0 0
3 0 0 0 0 0 0 0 0 0 0
4 0 0 0 0 0 1 0 0 0 0
5 0 0 0 0 0 0 1 0 0 0
6 0 0 0 0 0 0 0 1 0 0
7 0 0 0 1 0 0 0 0 0 0
8 0 0 0 0 1 0 0 0 0 0
9 0 0 0 0 0 0 1 0 0 0
10 0 0 0 0 0 0 0 1 0 0
11 0 0 1 0 0 0 0 0 0 0
12 0 1 0 0 0 0 0 0 0 0
13 0 0 1 0 0 0 0 0 0 0
14 0 0 0 1 0 0 0 0 0 0
15 0 0 0 0 1 0 0 0 0 0
16 0 0 0 0 0 0 0 0 0 0
17 0 0 0 0 0 0 1 0 0 0
18 0 0 0 0 0 1 0 0 0 0
19 0 0 0 1 0 0 0 0 0 0
20 0 0 0 1 0 0 0 0 0 0
;

z = 3065

R[*] :=
1 1
2 0
3 1
4 0
5 0
6 0
7 0
8 0
9 0
10 0
11 0
12 0
13 0
14 0
15 0
16 1
17 0
18 0
19 0
20 0
;

AMPL:

```
- Model Editor (Right):** Shows the AMPL model code for Assignment_5_4.mod.


```

param nF;
param nT;
param nD;

set I := {1..nF}; #set of flights requested
set T := {1..nT}; #set of time periods
set D := {1..nD}; #set of days

param A {I,T} >= 0; #displacement cost
param B {I,D} >= 0; #days
param C {I,D} >= 0; #capacity

var Y {I,T} >= 0 binary; #time allocated
var R {I} >= 0 binary; #num flights rejected

minimize z: sum {i in I, t in T, d in D} Y[i,t] * A[i,t] + sum {i in I} 1000 * R[i];

s.t. C1 {i in I}:
sum {t in T} Y[i,t] + R[i] == 1;

s.t. C2 {t in T, d in D}:
sum {i in I} Y[i,t] * B[i,d] <= C[t,d];

s.t. C3 {i in I}:
sum {t in T} A[i,t] * Y[i,t] <= 1;

```