Machinery Maintenance
MDP Example

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Problem Description

(Exercise 41, page 785, of Principles of O.R., by Harvey Wagner):

At the start of each day, an expensive piece of machinery is examined in order to determine whether it is in good working order, in need of minor maintenance, or requiring a major repair.

If the machinery is not in good working order, the company can utilize either of two maintenance-&-repair services:

- the We-Fix-It Service Company (charging $14 & $21 for minor & major repairs, respectively)
- the We-Try-To-Fix-It Service Company (charging $12 & $19 for minor & major repairs, respectively.

The We-Fix-It company does better quality work, reflected in the probabilities that at the beginning of the next day, the equipment is in good working order.

We seek a policy which minimizes expected cost per day.

States

i	name
1	Good condition
2	Minor faults
3	Major faults

Actions

k	name
1	Do nothing
2	Fix-it
3	Try-to-fix-it

Cost Matrix

k	name	1	2	3
1	Do nothing	0	999	999
2	Fix-it	999	14	21
3	Try-to-fix-it	999	12	19

(Rows ~ actions, Columns ~ states)

A value of 999 above signals
an infeasible action in a state.

States

i	name
1	Good condition
2	Minor faults
3	Major faults

Transition Probabilities

Action: Do nothing

from \ to	1	2	3
1	0.6	0.3	0.1
2	0	1	0
3	0	0	1

Action: Fix-it

from \ to	1	2	3
1	1	0	0
2	0.9	0.1	0
3	0.6	0.3	0.1

Action: Try-to-fix-it

from \ to	1	2	3
1	1	0	0
2	0.7	0.2	0.1
3	0.5	0.4	0.1

LP Tableau

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k:	1	2	3	2	3	RHS
i:	1	2	2	3	3	
Min	0	14	12	21	19	
	0.4	-0.9	-0.7	-0.6	-0.5	0
	-0.3	0.9	0.8	-0.3	-0.4	0
	1	1	1	1	1	1

i~state, k~action

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Iteration 0

Policy: (Cost= 5.37273)

State		Action	P{i}
1	Good condition	1 Do nothing	0.627273
2	Minor faults	3 Try-to-fix-it	0.272727
3	Major faults	2 Fix-it	0.1

Iteration 0

k:	1	2	3	2	3	
i:	1	2	2	3	3	rhs
Min	0	-1.19091	0	0	-0.909091	-5.37273
	1	-0.190909	0	0	0.0909091	0.627273
	0	1.09091	1	0	-0.0909091	0.272727
	0	0.1	0	1	1	0.1

i~state, k~action

Iteration 1

Policy: (Cost= 5.075)

State	Action	P{i}
1 Good condition	1 Do nothing	0.675
2 Minor faults	2 Fix-it	0.25
3 Major faults	2 Fix-it	0.075

Iteration 1

k:	1	2	3	2	3	
i:	1	2	2	3	3	rhs
Min	0	0	1.09167	0	-1.00833	-5.075
	1	0	0.175	0	0.075	0.675
	0	1	0.916667	0	-0.0833333	0.25
	0	0	-0.0916667	1	1.00833	0.075

i~state, k~action

Iteration 2

Policy: (Cost= 5)

State		Action	P{i}
1	Good condition	1 Do nothing	0.669421
2	Minor faults	2 Fix-it	0.256198
3	Major faults	3 Try-to-fix-it	0.0743802

Iteration 2

k:	1	2	3	2	3	
i:	1	2	2	3	3	rhs
Min	0	0	1	1	0	-5
	1	0	0.181818	-0.0743802	0	0.669421
	0	1	0.909091	0.0826446	0	0.256198
	0	0	-0.0909091	0.991736	1	0.0743802

i~state, k~action

Optimal Policy

State		Action
1	Good condition	1 Do nothing
2	Minor faults	2 Fix-it
3	Major faults	3 Try-to-fix-it