

Project 2: Starship Troopers

Artificial Intelligence

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ETC: 15 hours (deadline - 5 classes)

3-4 students per team

Please take your time on both quality and contents

Associate professor and assistant professors will not answer questions about the project.

SCALE: 50 POINTS

1. 10 POINTS
2. 15 POINTS
3. 10 POINTS
4. 15 POINTS



“VIOLENCE, NAKED FORCE, HAS SETTLED MORE ISSUES IN HISTORY THAN HAS ANY OTHER FACTOR.”

TASK 1: RELOCATE THE PRODUCTION

In the 23rd century, Earth has become a space-faring civilization. While colonizing new planets, humans have encountered an insectoid species known as Arachnids, with their home being the distant world Klendathu. The bugs appear to be little more than savage, unrelenting killing machines, although there are suggestions that they were provoked by the intrusion of humans into their habitats.

At a rich salesman, you don't need to perform our military service for the Federation. Our wealth comes from various factories which produce basics and stuff for armies. Since Klendathu has fallen, the war has intensified and spreads to the whole galaxy. Our factories aren't optimized; they produce all kinds of stuff when it costs a lot to bring material to the different industrial planets. You have to rethink how to produce in function of material costs and material needed to build stuff (only use material based on the planet).



Extraction cost of material by planets:

Planet Material	Dilithium	Duranium	Element Zero	Tritanium
Giedi Prime	1	1	1	0.1
Betelgeuse	0.5	0.9	1.2	0.3
Wallach IX	0.9	0.7	1.1	0.3
Lampadas	1.2	0.1	1	0.2
Ix	0.7	2	0.3	0.1

Costs in Mg of each material to build stuff:

Stuff Material	Dilithium	Duranium	Element Zero	Tritanium
Droideka	1	0.6	0.8	1.2
Vulture Fighter	0.9	1	0.1	1.3
T-droid	0.7	1.3	1	0.5
Hailfire droid	0.5	0.3	0.1	1
MagnaGuards	0.9	0.9	0.9	1.1

1. Find the price of each stuff for each planet (**1 POINT**)
2. Draw a table for the problem (**1.5 POINTS**)
3. Resolve the problem (**3 POINTS**)
4. Draw the problem as a graph (**1.5 POINTS**)
5. Solve the problem with excel (**3 POINTS**)

TASK 2: MOVING OUR TROOPS

Your factories run at full speed. The brand new equipment will allow having ascendancy on the Arachnids.

You have an unlimited stock compared to military needs. If they need more, they will provide you more funds. In order to limit your fuel expenses at most, your transport vessels will take only the bare minimum to make the journey.



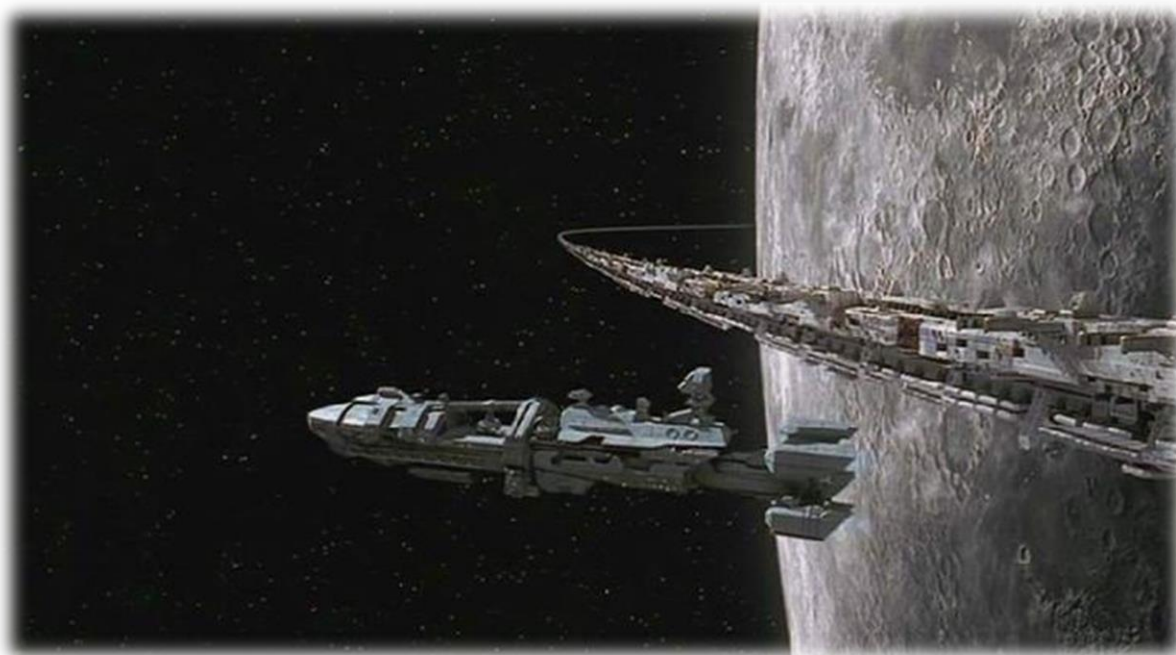
The cost in kilograms of Unobtainium of your Holtzmann reactors varies depending on the distance and gravity of the planets.

Cost of take-off	Giedi Prime (1)	Betelgeuse (2)	Wallach IX (3)	Lampadas (4)	Ix (5)
-	3.5e2	1.25e2	1.75e2	2.12e2	0.8e2

Cost of landing	Kharak (6)	Klendathu (7)	M6-117 (8)	Tallarn (9)	Dyson (10)	Gaea (11)	Onyx (12)	Discworld (13)	Htrae (14)
-	254	89	211	370	50	78	23	89	147

Since the capacity of your transport is limited, it is not always possible to make direct journeys between planet-factories and planet-training. To do this, you have to go through the orbital stations to refuel, so you lose some of the fuel during your stopover in order to perform the maneuvers. Here is a table

representing the loss in Unobtainium for a stopover on possible destinations.



Stepover fuel costs	Kharak (6)	Klendathu (7)	M6- 117 (8)	Tallarn (9)	Dyson (10)	Gaea (11)	Onyx (12)	Discworld (13)	Htrae (14)
	200	100	240	500	200	80	70	20	140

And a table showing the reachable planets from each of them and the fuel cost for the supra-liminal path.

To from	1	2	3	4	5	6	7	8	9	10	11	12	13	14
6	58	67	80	-	-	-	24	-	31	102	-	-	-	-
7	-	41	21	50	-	24	-	45	10	110	90	-	-	90
8	-	-	90	50	10	-	45	-	-	-	-	100	-	70
9	-	-	-	-	-	31	10	-	-	46	35	15	28	-
10	-	-	-	-	-	102	110	-	46	-	24	17	-	-
11	-	-	-	-	-	-	90	-	35	24	-	7	-	-
12	-	-	-	-	-	-	-	100	15	17	7	-	-	36
13	-	-	-	-	-	-	-	-	28	-	-	-	-	10
14	-	-	-	-	-	-	90	70	-	-	-	36	10	-

For example, case (i,j) means you leave the planet i for the planet j. The cost to travel from j to i is the same.

1. Graph without refueling stop
 - a. Draw the graph where costs are equal to used fuel (**1 POINT**)
 - b. Find all the shortest paths (**2.5 POINTS**)
 - c. Draw the tree of shortest paths (**1 POINT**)
2. Graph with refueling stop
 - a. Draw the graph where costs are equal to used fuel (**2 POINTS**)
 - b. Find all the shortest paths (**2.5 POINTS**)
 - c. Draw the tree of shortest paths (**1 POINT**)

TASK 3: MASS ATTACK

Your armies are ready to launch the final assault. The General Staff of the Federation located the last bastions of the Arachnids. You must prepare your troops in the utmost discretion before launching the attack simultaneously on several fronts (from lunar bases).



Holtzmann reactors leave a small disturbance in space-time during a journey. After skillful calculations, you have determined the maximum number of vessels that can pass through each interstellar route to the nearest lunar bases.

	Lunar 1	Lunar 2	Lunar 3	Lunar 4	Lunar 5	Lunar 6	Lunar 7	Lunar 8	Lunar 9
10	5	-	7	-	-	-	-	-	-
11	10	-	-	-	-	-	-	-	-
12	6	4	-	5	-	-	-	-	-
13	-	8	-	-	-	-	-	-	-
14	-	4	-	-	9	-	-	-	-
Lunar 1	-	2	7	8	-	-	-	-	-
Lunar 2	1	-	-	8	7	-	-	-	-
Lunar 3	4	-	-	3	-	5	5	2	-

Lunar 4	-	-	5	-	3	7	-	3	-
Lunar 5	-	-	-	4	-	-	-	1	10

Case (i,j) means you travel from i to j.

Stock the maximal number of troops at Lunar 5 to Lunar 9 (5, 6, 7, 8, 9). Your armies are ready! Let's go!



1. Show this problem as a flow problem (**1 POINT**)
2. Solve the problem (**3.5 POINT**)
3. Show the solution with a graph (**1.5 POINTS**)
4. Find the min-cut (**1.5 POINTS**)
5. Which edge of the cut can increase at most the global flow ? (**2.5 POINTS**)

TASK 4: TO FALL IN AGAIN!

The fighting is not going as well as expected. The Arachnid resistance is fierce and the losses of the Federation are counted in millions of soldiers and trillions of Earthos. Your production struggles to cover the losses and you have to rearrange your orders so as not to disadvantage a front.



Your productions in a number of troops (without distinction) are the following:

Giedi Prime	Betelgeuse	Wallach IX	Lampadas	Ix
600	400	500	450	350

And the requests for reinforcements are the following:

Front 1	Front 2	Front 3	Front 4	Front 5	Front 6	Front 7
500	300	400	250	250	600	300

You are financially on the edge of the abyss. In order to be able to keep the front in place for as long as possible, you must send reinforcements available by spending the least amount of fund (part of the transport is financed by the Federation, the leftovers is out of your pocket).

To From	Giedi Prime	Betelgeuse	Wallach IX	Lampadas	Ix
Front 1	1	3	5	4	5
Front 2	4	6	2	6	1
Front 3	5	1	5	3	2
Front 4	2	6	3	4	7
Front 5	3	4	1	6	7
Front 6	5	2	6	5	1
Front 7	3	5	4	2	3

This is not so simple. Of course, you cannot send infinite troops by from any place to any front. Routes are also defined par a limited flow as shown in the following table:

To From	Giedi Prime	Betelgeuse	Wallach IX	Lampadas	Ix
Front 1	200	105	135	95	65
Front 2	100	200	30	55	80
Front 3	125	25	50	75	90
Front 4	400	25	80	90	105
Front 5	95	120	70	50	110
Front 6	60	75	65	140	40
Front 7	80	55	140	100	200

1. Resolve the transportation problem
 - a. Show the problem as a bipartite graph with costs and flow (**1.5 POINT**)
 - b. Find the tableau (**2 POINTS**)
 - c. Resolve the problem with Stepping Stone method (**3.5 POINTS**)
2. Resolve the flow problem
 - a. Find an algorithm to solve the problem (min cost flow), explain it and show the flowchart (**4.5 POINTS**)
 - b. Show a solution (**3.5 POINTS**)