MIP & BIP Homework Assignment

- A first-time homeowner, Jill, is setting up her new house. She intends to do most of the home maintenance herself, but she has no tools. After researching essential tools on the Internet Jill developed a shopping list for tools. Unfortunately, she found many ways to acquire the tools, which could be purchased individually or in sets of varying composition. Moreover, she found many such sets at varying prices at Lowes, Home Depot, Amazon, and at other retail outlets. After making a list of the best price for each tool or set of tools, she constructed the table below where each row represents a tool that is needed and each column represents an individual tool or tool set. The last row indicates the price of each tool or tool set. A value of 1 in the body of the table indicates that a particular tool is included in a tool set, and a 0 indicates otherwise. The goal of Jill's problem is to figure out how to buy one of each tool at the lowest cost.
    a. What is the name of Jill's "classic" optimization problem?
    b. Write a formulation for this problem.
    c. Write a Python-Gurobi program to optimize this problem and legibly printout the optimal decision variable values and the optimal objective function value.
    d. Summarize the optimal purchase decision and why it makes sense in a well-crafted, succinct sentence.
    - Note that a "starter" Python file has been provided for you with the data in list structures.

	Set																												
Item	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Small, Straight Screwdriver	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Medium, Strainght Screwdriver	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Large, Straight Screwdriver	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Small, Philip Screwdriver	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Medium Philip Screwdriver	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
Large Philip Screwdriver	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
8-inch Crescent Wrench	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
12-inch Crescent Wrench	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Needle Nose Pliers	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Wire Cutters	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Small Adjustable Pliers	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1
Large Adjustable Pliers	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1
Screwdriver Bit Set	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Drill Bit Set	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Cordless Drill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Cordless Circular Saw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Chisel Set	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Framing Hammer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Finish Hammer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Cost	5	5	5	5	5	5	21	25	15	17	27	32	14	17	89	95	52	30	37	29	50	30	55	39	200	135	85	82	275	155

- A glass company, PerfectlyClear (PC), is considering becoming more vertically integrated, that is, increasing the span of its supply chain so that the company performs a greater number of the operations required to make glass in its float glass plants. (Here's a video of the float glass process.) Glass is heavy and fragile and so there tend to be many smaller float glass plants scattered around the United states rather than fewer and larger plants. This reduces the transportation cost from the glass plants to the final customers. It, however, increases the cost of transporting raw materials to the float glass plants. Because that transportation is usually done through railroad, it is less expensive than shipping glass via trucks as is done for a majority of the glass leaving the float glass plant. PC is considering purchasing its own silica mines and shipping silica via railroad to its 15 plants. Each plant uses 420 tons of silica per day and operates 365 days per year. Float glass plants cannot be easily or economically shut down and restarted. Once the float glass process is shut down, the glass in the melting stage of the process solidifies and needed to be chipped out. Furthermore, the refractory lining of the oven needs also to be replaced. Total startup costs to restart a plant are $40 million per plant, not counting the lost sales during the downtime. The body of the table below shows the transportation cost per ton from each potential mine site to each of PC's 15 plants. The bottom row shows the acquisition cost of each mine. The right-most column shows the number of tons of silica used by each plant. PC uses a standard plant design to increase the efficiency of building its plants and getting them online and so each plant uses the same number of tons of silica each year. A Python file has been provided with the silica transportation costs, the tons of silica used in each plant annually, and the purchase costs of the mine sites.

  PC's goal is to minimize the upfront cost of purchasing the mines plus the first year of transportation costs by determining which mines to buy and which plants should be supplied by which of the mines. Formulate the shipping quantities as integer variables. Create a legible printout from your Python-Gurobi formulation that displays the results below.

  a. Write a formulation for this problem.
  b. What is the minimum possible sum of mine acquisition and first-year transportation costs? (If the Python variable for your Gurobi model is `m`, the you may obtain the optimal objective function value after your program runs with the statement print `m.ObjVal`.)
  c. Which mines should be purchased?
  d. Which mines should serve which plants?
  e. Summarize the optimal purchase decision and why it makes sense to pursue the solution economically in a well-crafted statement of no more than two sentences.

- Note that a "starter" Python file has been provided for you with the problem data in list structures.

		Potential Mine Sites															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Annual Tons of Silica Used
Float Glass Plant	0	24.92	30.36	34.90	39.30	31.78	28.89	44.49	34.99	30.40	30.79	33.31	29.42	34.62	36.18	41.88	153,300
	1	35.57	21.70	36.79	43.38	31.42	40.79	30.96	29.92	29.62	25.74	41.77	32.04	40.69	43.05	30.46	153,300
	2	44.57	22.94	23.97	40.35	26.31	27.98	35.00	38.77	29.88	25.47	38.02	33.53	41.75	27.88	37.74	153,300
	3	36.38	36.78	38.07	26.37	29.46	32.75	26.71	30.67	30.15	30.96	39.77	37.08	30.97	37.20	29.04	153,300
	4	43.06	39.52	28.24	39.64	21.02	32.27	39.11	26.87	39.30	36.78	34.29	27.80	40.69	39.36	26.62	153,300
	5	40.00	40.78	30.37	29.06	36.83	23.30	27.66	34.10	25.21	35.97	33.24	43.08	34.48	25.04	27.67	153,300
	6	42.78	40.26	30.13	30.07	38.74	25.42	26.52	22.90	30.33	31.91	31.21	41.51	30.11	27.16	42.24	153,300
	7	28.51	37.04	33.64	40.15	31.57	31.21	38.05	20.55	40.37	37.04	39.44	40.03	41.89	40.68	28.46	153,300
	8	32.68	41.09	31.26	31.12	36.60	42.88	28.38	33.22	25.05	29.22	33.83	36.00	38.53	34.74	37.84	153,300
	9	32.83	31.23	39.85	29.23	21.06	35.46	44.64	37.50	31.33	21.34	42.79	41.56	37.13	42.00	31.39	153,300
	10	39.44	22.16	39.22	34.29	37.82	33.98	43.78	26.06	44.11	26.37	26.82	40.44	34.71	42.37	42.86	153,300
	11	34.41	39.82	27.01	33.52	28.79	29.19	42.17	28.96	39.16	39.48	39.45	26.71	24.97	35.39	41.33	153,300
	12	27.51	35.59	26.86	45.97	32.64	34.21	45.88	36.42	32.76	28.71	36.66	36.66	23.18	26.14	26.42	153,300
	13	29.01	40.13	28.84	43.70	32.75	29.23	33.11	32.37	25.10	22.92	34.16	27.38	26.28	24.67	39.63	153,300
	14	26.07	28.96	33.83	36.53	32.95	28.25	32.21	36.24	29.18	22.37	30.78	26.84	36.74	30.18	26.33	153,300
	Purchase Cost	9,355,730	4,652,163	9,908,390	8,379,730	6,946,479	4,760,629	4,880,341	9,804,748	6,100,783	7,224,557	7,756,098	4,015,446	10,580,870	8,088,620	10,866,700	