

Diet Problems

Text Reference: Section 1.10, p. 93

The purpose of this set of exercises is to provide examples of vector equations which result from balancing nutrients in a diet.

Section 1.10 shows how use a vector equation

$$x_1\mathbf{a}_1 + x_2\mathbf{a}_2 + \dots + x_n\mathbf{a}_n = \mathbf{b}$$

to model a diet with a specified nutritional intake. Each vector \mathbf{a}_i lists the nutrient composition of one unit (usually 100 grams) of foodstuff, and the corresponding weight is the variable that represents the amount (number of units) of that foodstuff to be used in the diet. The vector \mathbf{b} lists the amount of each nutrient that must be in the diet.

Table 2 below is a listing of the nutritional value of many foods found in a typical kitchen. The nutrients are given per 100 grams of foodstuff. This data is taken from the USDA Nutrient Database for Standard Reference available at the United States Department of Agriculture website, <http://www.nal.usda.gov/fnic/foodcomp>. The columns represent respectively the following foodstuffs: beef, brussels sprouts, carrots, chicken soup, egg, feta cheese, grapefruit, lentils, lettuce, milk, mushrooms, oil, onion, rice, salad dressing, salmon, soy sauce, spinach, tomato, and vanilla ice cream. Table 1 gives the standard serving size for each of these foodstuffs, and also gives a key to the columns in Table 2.

Key Number	Foodstuff	Serving Size
1	Beef	6 oz. = 170 g
2	Brussels Sprouts	1/2 cup = 78 g
3	Carrots	1 carrot = 61 g
4	Chicken Soup	1 cup = 240 g
5	Egg	1 egg = 61 g
6	Feta Cheese	1/4 cup = 38 g
7	Grapefruit	1/2 fruit = 123 g
8	Lentils	1 cup = 198 g
9	Lettuce	1/2 cup = 28 g
10	Milk	1 cup = 244 g
11	Mushrooms	1/2 cup = 35 g
12	Oil	1 Tbsp. = 13.5 g
13	Onion	1 onion = 110 g
14	Rice	1 cup = 158 g
15	Salad Dressing	1 cup = 250 g
16	Salmon	1/2 fillet = 124 g
17	Soy Sauce	1 Tbsp. = 18 g
18	Spinach	1 cup = 180 g
19	Tomato	1 tomato = 123 g
20	Vanilla Ice Cream	1/2 cup = 66 g

Table 1: Serving Sizes of Various Foodstuffs

Nutrient	1	2	3	4	5	6	7	8	9	10
Calories kcal	215	39	43	73	152	263	30	116	14	61.44
Protein g	26	2.55	1.03	5.3	10.33	14.2	0.55	9.02	1.62	3.29
Fat g	11.5	0.51	0.19	2.5	11.44	21.3	0.1	0.38	0.2	3.34
Carbohydrates g	0	8.6	10.1	7.1	1.04	4.09	7.68	20.14	2.37	4.66
Calcium mg	7	36	27	10	42	492.5	11	19	36	119.4
Iron mg	3.1	1.2	0.5	0.6	1.19	0.65	0.12	3.33	1.1	0.05
Magnesium mg	27	20	15	4	9	19.2	8	36	6	13.44
Phosphorus mg	211	56	44	30	148	337	9	180	45	93.4
Potassium mg	367	317	323	45	101	61.8	129	369	290	151.5
Sodium mg	69	21	35	354	270	1116	0	2	8	49
Zinc mg	5290	0.33	0.2	0.4	0.92	2.88	0.07	1.27	0.25	0.38
Copper mcg	0.143	0.083	0.047	0.1	0.013	0.032	0.044	0.251	0.037	0.01
Vitamin C mg	0	62	9.3	0	0	0	38.1	1.5	24	0.94
Thiamine mg	0.11	0.107	0.097	0.03	0.044	0.154	0.034	0.169	0.1	0.038
Riboflavin mg	0.25	0.08	0.059	0.07	0.399	0.844	0.02	0.073	0.1	0.162
Niacin mg	4.63	0.607	0.928	1.8	0.058	0.991	0.191	1.06	0.5	0.084
Pantothenic Acid mg	0.34	0.252	0.197	15	0.934	0.967	0.283	0.638	0.17	0.314
Vitamin B6 mg	0.4	0.178	147	0.02	0.109	0.424	0.042	0.178	0.047	0.042
Vitamin B12 mcg	2.27	0	0	0.13	0.7	1.69	0	0	0	0.357
Vitamin A IU	0	719	28129	509	654	447	259	8	2600	126

Nutrient	11	12	13	14	15	16	17	18	19	20
Calories kcal	25	884	38	130	448.8	149	60	23	21	201
Protein g	2.09	0	1.16	2.69	0	25.56	10.51	2.9	0.85	3.5
Fat g	0.42	100	0.16	0.28	50.1	4.42	0.1	0.26	0.33	11
Carbohydrates g	4.65	1	8.63	28.17	2.5	0	5.57	3.75	4.64	23.6
Calcium mg	5	0.18	20	10	0	17	20	136	5	128
Iron mg	1.24	0.38	0.22	1.2	0	0.99	2.38	3.57	0.45	0.09
Magnesium mg	10	0.01	10	12	0	33	40	87	11	14
Phosphorus mg	104	1.22	33	43	0	295	130	56	24	105
Potassium mg	370	0	157	35	7.5	414	212	466	222	199
Sodium mg	0.4	0.04	3	1	0.5	86	5586	70	9	80
Zinc mg	0.73	0.06	0.19	0.49	0	0.71	0.43	0.76	0.09	0.69
Copper mcg	0.492	0	0.06	0.069	0	0.099	0.135	0.174	0.074	0.023
Vitamin C mg	3.5	0	6.4	0	0	0	0	9.8	19.1	0.6
Thiamine mg	0.102	0	0.042	0.163	0	0.196	0.059	0.095	0.059	0.041
Riboflavin mg	0.449	0	0.02	0.013	0	0.073	0.152	0.236	0.048	0.24
Niacin mg	40116	0	0.148	1.476	0	8.526	3.951	0.49	0.628	0.116
Pantothenic Acid mg	2.2	0	0.106	0.39	0	0.865	0.376	0.145	0.247	0.581
Vitamin B6 mg	0.097	0	0.116	0.093	0	0.231	0.2	0.242	0.08	0.048
Vitamin B12 mcg	0	0	0	0	0	3.46	0	0	0	0.39
Vitamin A IU	0	0	0	0	0	136	0	8190	623	409

Table 2: Nutritional Values of Various Foods per 100 g of Foodstuff

Questions:

- Low carbohydrate diets are popular for weight loss. Compute (by hand) the amount of carbohydrates in each of the following dishes, and determine which would be better for such a dieter to choose. You will first need to use Table 1 to convert the kitchen measures into 100 gram units, then use Table 2 to find the amount of carbohydrates in each ingredient.

Spinach omelet: 1/4 cup spinach, 2 eggs, 1/8 cup milk, 1/2 Tbsp. oil

Greek salad: 1 cup lettuce, 1/4 cup feta cheese, 1/2 of a tomato, 1/8 cup salad dressing

- To make a stir fry, fry beef and onions in a wok with oil, and top it with soy sauce.
 - You would like to make a stir fry with a total of 6 g carbohydrates, 50 g protein, and 3.5 mg vitamin C, and you'd like this dish to contain only 575 calories. Use Table 2 to set up a matrix equation which could be used to determine whether it is possible to make such a stir fry. Describe the steps you take to produce the vectors in the equation.
 - Find a precise recipe for the stir fry in part a). Convert your amounts to common kitchen measures using Table 1.

- Table 2 has been incorporated into the matrix A in the m-file **diet.m** accompanying this file.

215	39	43	73	152	263	30	116	14	61.44	25	884	38	130448.8	149	60	23	21	201	
26	2.55	1.03	5.3	10.33	14.2	0.55	9.02	1.62	3.29	2.09	0	1.16	2.69	0	25.56	10.51	2.9	0.85	3.5
11.5	0.51	0.19	2.5	11.44	21.3	0.1	0.38	0.2	3.34	0.42	100	0.16	0.28	50.1	4.42	0.1	0.26	0.33	11
0	8.6	10.1	7.1	1.04	4.09	7.68	20.14	2.37	4.66	4.65	1	8.63	28.17	2.5	0	5.57	3.75	4.64	23.6
7	36	27	10	42	492.5	11	19	36	119.4	5	0.18	20	10	0	17	20	136	5	128
3.1	1.2	0.5	0.6	1.19	0.65	0.12	3.33	1.1	0.05	1.24	0.38	0.22	1.2	0	0.99	2.38	3.57	0.45	0.09
27	20	15	4	9	19.2	8	36	6	13.44	10	0.01	10	12	0	33	40	87	11	14
211	56	44	30	148	337	9	180	45	93.4	104	1.22	33	43	0	295	130	56	24	105
367	317	323	45	101	61.8	129	369	290	151.5	370	0	157	35	7.5	414	212	466	222	199
69	21	35	354	270	1116	0	2	8	49	0.4	0.04	3	1	0.5	86	5586	70	9	80
5290	0.33	0.2	0.4	0.92	2.88	0.07	1.27	0.25	0.38	0.73	0.06	0.19	0.49	0	0.71	0.43	0.76	0.09	0.69
0.143	0.083	0.047	0.1	0.013	0.032	0.044	0.251	0.037	0.01	0.492	0	0.06	0.069	0	0.099	0.135	0.174	0.074	0.023
0	62	9.3	0	0	0	38.1	1.5	24	0.94	3.5	0	6.4	0	0	0	0	9.8	19.1	0.6
0.11	0.107	0.097	0.03	0.044	0.154	0.034	0.169	0.1	0.038	0.102	0	0.042	0.163	0	0.196	0.059	0.095	0.059	0.041
0.25	0.08	0.059	0.07	0.399	0.844	0.02	0.073	0.1	0.162	0.449	0	0.02	0.013	0	0.073	0.152	0.236	0.048	0.24
4.63	0.607	0.928	1.8	0.058	0.991	0.191	1.06	0.5	0.084	40116	0	0.148	1.476	0	8.526	3.951	0.49	0.628	0.116
0.34	0.252	0.197	15	0.934	0.967	0.283	0.638	0.17	0.314	2.2	0	0.106	0.39	0	0.865	0.376	0.145	0.247	0.581
0.4	0.178	147	0.02	0.109	0.424	0.042	0.178	0.047	0.042	0.097	0	0.116	0.093	0	0.231	0.2	0.242	0.08	0.048
2.27	0	0	0.13	0.7	1.69	0	0	0	0.357	0	0	0	0	0	3.46	0	0	0	0.39
0	719	28129	509	654	447	259	8	2600	126	0	0	0	0	0	136	0	8190	623	409

What does the j th column in this matrix represent? Which entry in this matrix tells you how much vitamin C is found in 100 g of vanilla ice cream?

4. A particularly math-savvy sumo wrestler wanted to adhere to a strict diet to maintain his weight and strength. Table 3 lists his desired nutritional intake for one day. The entries in Table 3 are stored in the vector \mathbf{v}_1 which is in the m-file `diet.m`. Using Table 2 he was able to decide on an optimal diet to give him this combination of nutrients. How much of each of the above foods were in his diet?

Nutrient	Amount
Calories	8279.12 kcal
Protein	608.81 g
Fat	387.6 g
Carbohydrates	604.48 g
Calcium	4067.42 mg
Iron	93.34 mg
Magnesium	1714.73 mg
Phosphorus	8488.03 mg
Potassium	18023.48 mg
Sodium	8846.38 mg
Zinc	36009.75 mg
Copper	6.67 mcg
Vitamin C	604.06 mg
Thiamine	6.77 mg
Riboflavin	10.61 mg
Niacin	28212.10 mg
Pantothenic Acid	103.11 mg
Vitamin B6	189.81 mg
Vitamin B12	51.78 mcg
Vitamin A	95382.93 IU

Table 3: Sumo Wrestler Diet

```
 $\mathbf{v} = [8279.12, 608.81, 387.60, 604.48, 4067.42, 93.34, 1714.73,$   

 $8488.03, 18023.48, 8846.38, 36009.75, 6.67, 604.06, 6.77,$   

 $10.61, 28212.10, 103.11, 189.81, 51.78, 95382.93];$ 
```

5. The United States Food and Drug Administration (FDA) provides Recommended Daily Values for use on food labels. Table 4 gives the FDA's recommendations, which are also stored in the vector `v2` which is in the accompanying m-file `diet.m`. Is it possible to combine the foods from the table to approximate these nutritional values?

Nutrient	Amount
Calories	2000 kcal
Protein	50 g
Fat	65 g
Carbohydrates	300 g
Calcium	1000 mg
Iron	18 mg
Magnesium	400 mg
Phosphorus	1000 mg
Potassium	3500 mg
Sodium	2400 mg
Zinc	15 mg
Copper	2000 mcg
Vitamin C	60 mg
Thiamine	2 mg
Riboflavin	2 mg
Niacin	20 mg
Pantothenic Acid	10 mg
Vitamin B6	2 mg
Vitamin B12	6 mcg
Vitamin A	5000 IU

Table 4: FDA Recommended Daily Values

```
v2 = [2000  50 65  300  1000  18  400  1000  3500  2400  15  2000  60
      2  2   20  10  2   6   5000 ];
```

Reference:

U.S. Department of Agriculture, Agricultural Research Service. 2001. USDA Nutrient Database for Standard Reference, Release 14. Nutrient Data Laboratory Home Page, <http://www.nal.usda.gov/fnic/foodcomp>