Pack that Bag!
A Hands-On Game about Optimization

You are participating in a TV game show where each contestant is given an empty duffel bag that can carry up to 26 pounds. In front of you, there are twelve household items, each labeled with their corresponding weight and dollar value. It is not possible to carry all items in the bag because of the 26-pound limit (assume space is not a problem). Your goal is to choose which items to pack in the bag so that the total dollar value of the items inside the bag is maximized, that is, as large as possible. The item details are as follows:

	Items											
	Computer	Keurig	Printer	PlayStation	Projector	Robo Vac	Wine	Tablet	Painting	Speaker	Toaster	Camera
Weight (lbs)	7	5	6	5	4	5	4	3	3	3	3	2
Value ($)	290	240	238	200	190	190	161	145	130	123	110	100

Each colored rectangle below represents an item. The length of the rectangle's longest side is proportional to that item's weight.

Computer **$290, 7 lbs**	**Printer** **$238, 6 lbs**	**Camera** **$100, 2lbs**	
Keurig **$240, 5 lbs**	**PlayStation** **$200, 5 lbs**	**Robo Vac** **$190, 5 lbs**	**Toaster** **$110, 3 lbs**

Projector **$190, 4 lbs**	**Wine** **$161, 4 lbs**	**Tablet** **$145, 3 lbs**	**Painting** **$130, 3 lbs**	**Speaker** **$123, 3 lbs**

The strip below is 26 units long, representing how much can fit in your bag. Packing rectangles inside this strip simulates the packing of the bag. Using a pair of scissors, cut out the colored rectangles above and try to pack them in your bag (the strip) as best as you can.

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

For example, this packing of items weighs 25 lbs and is worth $1,049. Can you do better?

Tablet **$145, 3 lbs**	**Projector** **$190, 4 lbs**	**Painting** **$130, 3 lbs**	**Robo Vac** **$190, 5 lbs**	**Speaker** **$123, 3 lbs**	**Wine** **$161, 4 lbs**	**Toaster** **$110, 3 lbs**

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Additional Questions for Discussion:

How do you know for sure that your solution is the best possible? What arguments would you use to convince someone that your solution cannot be improved?

What assumptions or simplifications from a real-life situation were made while solving this problem?

Your final solution may have packed 6 or 7 items in the bag. What if there was a requirement that at most 5 items be packed and you had to pick the 5 most valuable items? What would your solution be in this case? Do you see that the group of 5 best items is not necessarily a sub-group of the 6 or 7 best items? Is this counterintuitive to you? If so, can you try to understand why this happens?

Interestingly, there are many other real-life problems that can be seen as if they were about packing "items" in a "bag," where the items and the bag are replaced with other things. For example, say you have several projects you would like to work on, but not enough time to do them all. Each project, if completed, has an intrinsic benefit (for example, it teaches you a new skill). The projects are the "items," their benefits play the role of the items' dollar values, and the time you have available is the bag's weight limit. The time it takes to complete each project is like the weight of each item. So you want to use your time (pack your "bag") in the best way possible. Can you think of other examples like this?