

Dear Dr. Wiggins –

It's us (Conner, Molly, Madi, Shelby, Kensington, Kelsey, Aidan, Kirby, Jon, Kyle, Zach, Jackson, Maya, Tyler, Meredith, Elliot, Justin, Leonard, Grace, Drew, Josie, and Rice) again. We'd like to share our work on Farmer John's rock(s) with you.

We decided to do the four-rock problem first. To be honest, Drew was all over it before many of us really got a chance to dig in. (He's a rock star.) Drew realized that using rocks on both pans of the beam opened up a lot of options. After some trials, he noticed that spreading out the weights of the rocks provided flexibility. And following some trials and adjustments, he revealed to the class that a one-pound rock, a three-pound rock, a nine-pound rock, and a twenty-seven-pound rock would suffice to weigh anything between one and forty pounds.

Our verification, compiled by Conner, Molly, Madi, Shelby, and Kensington, can be found on the next page.

Farmer John: Rocks 1, 3, 9, and 27

1 lb Hay	Hay	<i>balances</i>	Rock 1
2 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3
3 lb Hay	Hay	<i>balances</i>	Rock 3
4 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3
5 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 9
6 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 9
7 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 9
8 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 9
9 lb Hay	Hay	<i>balances</i>	Rock 9
10 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 9
11 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 9
12 lb Hay	Hay	<i>balances</i>	Rock 3 + Rock 9
13 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3 + Rock 9
14 lb Hay	Hay + Rock 1 + Rock 3 + Rock 9	<i>balances</i>	Rock 27
15 lb Hay	Hay + Rock 3 + Rock 9	<i>balances</i>	Rock 27
16 lb Hay	Hay + Rock 3 + Rock 9	<i>balances</i>	Rock 1 + Rock 27
17 lb Hay	Hay + Rock 1 + Rock 9	<i>balances</i>	Rock 27
18 lb Hay	Hay + Rock 9	<i>balances</i>	Rock 27
19 lb Hay	Hay + Rock 9	<i>balances</i>	Rock 1 + Rock 27
20 lb Hay	Hay + Rock 1 + Rock 9	<i>balances</i>	Rock 3 + Rock 27
21 lb Hay	Hay + Rock 9	<i>balances</i>	Rock 3 + Rock 27
22 lb Hay	Hay + Rock 9	<i>balances</i>	Rock 1 + Rock 3 + Rock 27
23 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 27
24 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 27
25 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 27
26 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 27
27 lb Hay	Hay	<i>balances</i>	Rock 27
28 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 27
29 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 27
30 lb Hay	Hay	<i>balances</i>	Rock 3 + Rock 27
31 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3 + Rock 27
32 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 9 + Rock 27
33 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 9 + Rock 27
34 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 9 + Rock 27
35 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 9 + Rock 27
36 lb Hay	Hay	<i>balances</i>	Rock 9 + Rock 27
37 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 9 + Rock 27
38 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 9 + Rock 27
39 lb Hay	Hay	<i>balances</i>	Rock 3 + Rock 9 + Rock 27
40 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3 + Rock 9 + Rock 27

With that problem conquered, we moved on to the three-rock episode. Drew didn't like our chances here. With all his experience in adjusting the four rocks to the perfect weights, using just three didn't look good.

We then remembered an earlier part of your email when you commented that future texts should leave out material to make problems more interesting. Were you doing that to us here, we wondered? Probably so. Therefore, we assumed that we had poetic license to create a little backstory for Farmer John.

So Farmer John has his rocks returned from Farmer Joe and is, at first, heartbroken to see that his forty-pound rock has become a one-pound rock, a three-pound rock, and a thirty-six pound rock. The original rock was used to measure the perfect amount of hay, and can still do that as a trio ... and now the rocks are now a bit more portable, for those days that are hard on the back. So, things are looking up.

Farmer John also realizes that he now has the capability to measure other weights of hay. Using both sides of the balance, he can accurately measure hay in the amounts compiled by Kelsey, Aidan, Kirby, Jon, and Kyle and shown on the next page.

Farmer John: Rocks 1, 3, and 36

1 lb Hay	Hay	<i>balances</i>	Rock 1
2 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3
3 lb Hay	Hay	<i>balances</i>	Rock 3
4 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3
5 lb Hay		<i>impossible</i>	
6 lb Hay		<i>impossible</i>	
7 lb Hay		<i>impossible</i>	
8 lb Hay		<i>impossible</i>	
9 lb Hay		<i>impossible</i>	
10 lb Hay		<i>impossible</i>	
11 lb Hay		<i>impossible</i>	
12 lb Hay		<i>impossible</i>	
13 lb Hay		<i>impossible</i>	
14 lb Hay		<i>impossible</i>	
15 lb Hay		<i>impossible</i>	
16 lb Hay		<i>impossible</i>	
17 lb Hay		<i>impossible</i>	
18 lb Hay		<i>impossible</i>	
19 lb Hay		<i>impossible</i>	
20 lb Hay		<i>impossible</i>	
21 lb Hay		<i>impossible</i>	
22 lb Hay		<i>impossible</i>	
23 lb Hay		<i>impossible</i>	
24 lb Hay		<i>impossible</i>	
25 lb Hay		<i>impossible</i>	
26 lb Hay		<i>impossible</i>	
27 lb Hay		<i>impossible</i>	
28 lb Hay		<i>impossible</i>	
29 lb Hay		<i>impossible</i>	
30 lb Hay		<i>impossible</i>	
31 lb Hay		<i>impossible</i>	
32 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 36
33 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 36
34 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 36
35 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 36
36 lb Hay	Hay	<i>balances</i>	Rock 36
37 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 36
38 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 36
39 lb Hay	Hay	<i>balances</i>	Rock 3 + Rock 36
40 lb Hay	Hay	<i>balances</i>	Bale 40

"That's kinda cool," thought Farmer John. He couldn't help wishing for more ... but with these three rocks, those are the only weights he can manage. So, it's back to work on his forty-pound hay bales.

Farmer John finished up his first bale with his new rock configuration and threw it to the side. "You know," Farmer John thought, "when I finish a bale, why don't I just leave it in the pan and measure the next bale against it? After all, it's just like having a forty-pound rock."

It's just like having a forty-pound rock!

Farmer John realized that if he considers his finished bale as a forty-pound rock, he can now measure even more weights of rocks! His new possibilities, compiled by Zach, Jackson, Maya, Tyler, and Meredith, can be found on the next page.

Farmer John: Rocks 1, 3, and 36 AND Bale 40

1 lb Hay	Hay	<i>balances</i>	Rock 1
2 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3
3 lb Hay	Hay	<i>balances</i>	Rock 3
4 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3
5 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 1 + Bale 40
6 lb Hay	Hay + Rock 1 + Rock 36	<i>balances</i>	Rock 3 + Bale 40
7 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 3 + Bale 40
8 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 1 + Rock 3 + Bale 40
9 lb Hay		<i>impossible</i>	
10 lb Hay		<i>impossible</i>	
11 lb Hay		<i>impossible</i>	
12 lb Hay		<i>impossible</i>	
13 lb Hay		<i>impossible</i>	
14 lb Hay		<i>impossible</i>	
15 lb Hay		<i>impossible</i>	
16 lb Hay		<i>impossible</i>	
17 lb Hay		<i>impossible</i>	
18 lb Hay		<i>impossible</i>	
19 lb Hay		<i>impossible</i>	
20 lb Hay		<i>impossible</i>	
21 lb Hay		<i>impossible</i>	
22 lb Hay		<i>impossible</i>	
23 lb Hay		<i>impossible</i>	
24 lb Hay		<i>impossible</i>	
25 lb Hay		<i>impossible</i>	
26 lb Hay		<i>impossible</i>	
27 lb Hay		<i>impossible</i>	
28 lb Hay		<i>impossible</i>	
29 lb Hay		<i>impossible</i>	
30 lb Hay		<i>impossible</i>	
31 lb Hay		<i>impossible</i>	
32 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 36
33 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 36
34 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 36
35 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 36
36 lb Hay	Hay	<i>balances</i>	Rock 36
37 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 36
38 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 36
39 lb Hay	Hay	<i>balances</i>	Rock 3 + Rock 36
40 lb Hay	Hay	<i>balances</i>	Bale 40

This was better ... but still not completely fulfilling. Unfortunately, Farmer John now had an insatiable desire to command his destiny.

"Eight, but not nine. Eight, but not nine," he mumbled. "I can't bail myself out of this." And then, a shock of realization. "But maybe I can *bale* myself out of this!"

Farmer John loaded Rock 1, Rock 3, and Bale 40 on one pan, Rock 36 and some loose hay on the other until it balanced. He grabbed that loose hay and bundled it. "That, sports fans, is an eight-pound hay bale. If I can make an eight," he reasoned, "I can make a nine. If I can make a nine, I can make a ten."

And that's just what he did. When Mrs. Farmer John awoke the next morning, she was greeted by a beaming, but bleary-eyed Farmer John and forty different-sized bales of hay.

But that turned out to be not such a good thing.

"Farmer John," she shouted in a voice that woke Farmer Joe miles away, "what in tarnation are you intending with forty different-sized bales of hay?"

"Don't you see? I've done it! I can measure any integral weight of hay between zero and forty pounds," he exclaimed.

"Oh, you've done it all right," Mrs. Farmer John countered. "And now you're going to undo it. We will not be living under your unnecessary piles of hay."

"Unnecessary? Unnecessary?! Woman, did you hear me say that we I can weigh any amount? Any amount!"

"Farmer John, we use forty-pound bales," Mrs. Farmer John said. "Forty. We don't need these others. Get rid of them."

"Can I at least keep the nine-pound bale and the twenty-seven pound bale," Farmer John asked. "Those, put with the rocks I have would be enough ..."

"Farmer John, maybe you could instead use the rocks in your head," Mrs. Farmer John snapped. "Our hay is for taking to our livestock and taking to market ... not for playing with. You make forty-pound bales; that's it. If I see anything else, I will throw my bowling ball at you!"

And with that, Mrs. Farmer John stormed out, leaving Farmer John with some bales to consolidate. "Her bowling ball," he muttered. "She hasn't used that thing for years ... she wouldn't even know if it were missing. Wait ... bowling ball? Bowling ball! Hey! Hay!"

Farmer John rushed into the house and down to the basement storage. He pushed aside his five- and ten-pound dumbbells, the twenty-pound bag of cement, the thirty-pound bag of dog food, and grabbed Mrs. Farmer John's twelve-pound bowling ball.

On the way back up the stairs, he turned back to look at the things he had pushed out of the way. Oops.

"It doesn't matter now," he thought. "With my rocks, the forty-pound bale that I'm allowed to keep, and this bowling ball, I can measure anything! Anything, I say!" Our verification, compiled by Elliot, Justin, Leonard, Grace, and Josie, follows.

Farmer John: Rocks 1, 3, and 36, Bale 40, AND Ball 12

1 lb Hay	Hay	<i>balances</i>	Rock 1
2 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3
3 lb Hay	Hay	<i>balances</i>	Rock 3
4 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3
5 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 1 + Bale 40
6 lb Hay	Hay + Rock 1 + Rock 36	<i>balances</i>	Rock 3 + Bale 40
7 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 3 + Bale 40
8 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Ball 12
9 lb Hay	Hay + Rock 3	<i>balances</i>	Ball 12
10 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Ball 12
11 lb Hay	Hay + Rock 1	<i>balances</i>	Ball 12
12 lb Hay	Hay	<i>balances</i>	Ball 12
13 lb Hay	Hay	<i>balances</i>	Rock 1 + Ball 12
14 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Ball 12
15 lb Hay	Hay	<i>balances</i>	Rock 3 + Ball 12
16 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 3 + Ball 12
17 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 1 + Ball 12 + Bale 40
18 lb Hay	Hay + Rock 1 + Rock 36	<i>balances</i>	Rock 3 + Ball 12 + Ball 40
19 lb Hay	Hay + Rock 36	<i>balances</i>	Rock 3 + Ball 12 + Bale 40
20 lb Hay	Hay + Rock 1 + Rock 3 + Ball 12	<i>balances</i>	Rock 36
21 lb Hay	Hay + Rock 3 + Ball 12	<i>balances</i>	Rock 36
22 lb Hay	Hay + Rock 3 + Ball 12	<i>balances</i>	Rock 1 + Rock 36
23 lb Hay	Hay + Rock 1 + Ball 12	<i>balances</i>	Rock 36
24 lb Hay	Hay + Ball 12	<i>balances</i>	Rock 36
25 lb Hay	Hay + Ball 12	<i>balances</i>	Rock 1 + Rock 36
26 lb Hay	Hay + Rock 1 + Ball 12	<i>balances</i>	Rock 3 + Rock 36
27 lb Hay	Hay + Rock 1 + Ball 12	<i>balances</i>	Bale 40
28 lb Hay	Hay + Ball 12	<i>balances</i>	Bale 40
29 lb Hay	Hay + Ball 12	<i>balances</i>	Rock 1 + Bale 40
30 lb Hay	Hay + Rock 1 + Ball 12	<i>balances</i>	Rock 3 + Bale 40
31 lb Hay	Hay + Ball 12	<i>balances</i>	Rock 3 + Bale 40
32 lb Hay	Hay + Rock 1 + Rock 3	<i>balances</i>	Rock 36
33 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 36
34 lb Hay	Hay + Rock 3	<i>balances</i>	Rock 1 + Rock 36
35 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 36
36 lb Hay	Hay	<i>balances</i>	Rock 36
37 lb Hay	Hay	<i>balances</i>	Rock 1 + Rock 36
38 lb Hay	Hay + Rock 1	<i>balances</i>	Rock 3 + Rock 36
39 lb Hay	Hay + Rock 1	<i>balances</i>	Bale 40
40 lb Hay	Hay	<i>balances</i>	Bale 40

We hope this works, Dr. Wiggins. Thanks again for the fun!

Yours in heavy lifting,

Josie Weidner

Tyler Ralsor

Grace Taylor

Kirby Hart

Mr. Rice's Algebra Class
East Tipp Middle School
Corner Bridge

Kyle Howell

Jackson

Thomas & Pi-Lawlor Kelsey Galbreath

Mally Brunton

Elliot Schendel

Quinton Sigo

Madi Campbell

Meredith Roberts

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Jon Hillery

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