The Tale of

Daisy Rabbit

and the

Autumn Festival

By Ayal Kaffman

It was a brisk autumn day over the lush countryside, where a sharp breath of wind passed through the tall reeds and grasses. The trees in the thickets were laden with rich, auburn leaves which quivered and shook. The sky was pale blue, blending into the hills where mists had only just begun to drift away. The forest floor was damp and soft, covered in brown mushrooms and pine needles. Beneath a winding hedgerow, near the lane, there was a cottage, its door overgrown with plants. It was cozy and warm, and it belonged to Daisy Rabbit.

Daisy Rabbit sat in the kitchen. She was most clever and quite talented with maths. Before her, she had an old and faded book on trigonometry, which she read as she drank her tea and warmed by the fire. Often, she turned to her notebook to write a function or concept. It didn't take long before her daughters woke up, and headed to the kitchen. "G'morning," Clover said, the older of the two. Little Ivy only yawned. "What're you doing mum?" asked Clover, peering at the books. "I'm studying for work today, I've got a bundle of odd jobs to do today before the festival, and they all involve measuring with trigonometry," Daisy responded.

"Come, Clover, sit with me and I'll explain all this," Daisy said. "Sine, Cosine, and Tangent are 3 trigonometric functions used to calculate unknown lengths of sides and measures of angles in right triangles." Daisy Rabbit took out a sheet of paper and wrote down 3 functions. "From an angle," she began, "A triangle has 3 sides. These are the opposite, adjacent, and hypotenuse. The opposite is across from the chosen, non-90°, angle. The adjacent is next to the angle. The hypotenuse is directly across from the 90° angle and is longer than both others. Now, these are the trigonometric functions I will need:"

$Sin(A) =$ opposite/hypotenuse

$Cos(A) =$ adjacent/hypotenuse

$Tan(A) =$ opposite/adjacent

Clover enjoyed maths immensely. Although she had not been able to make heads or tails of these words before, she began to understand. "What does Sin^{-1} mean?" she asked curiously. "$Sin^{-1}(X)$ means the angle whose sin is X." Clover thought for a moment. "D'you think I could come with you today?" She asked, spreading jam on her toast. "Of course, my dear. I'm glad you're interested," responded Daisy. She was always looking to foster her daughters' love of education. "After breakfast, we'll need some items, if you wouldn't mind getting them." Clover swallowed her toast with alacrity before rushing off to grab a surveyor's wheel, a ruler, and a protractor. Soon they were prepared, and off to do a good job.

The day was mild and dark with the sun hiding behind thick, white clouds as Daisy Rabbit and Clover walked through the auburn thicket. "Let's practice the trigonometric functions," Daisy Rabbit said as they came upon a low wall. It was made of stone and covered in ivy. A wooden ladder leaned against it like a stile. Daisy took her wooden ruler and measured the height of the wall and the distance between it and the bottom of the ladder. "The wall is exactly **1** meter tall, and the ladder is **0.70** meters from the base of the wall. Now, little one, do you think you could find the angle between the ladder and the ground and the length of the ladder?"

Calculations for the Angle:
$$\text{Tan} A = 1/0.7$$
$$A = \text{Tan}^{-1}(1/0.7)$$
$$A = 55.01°$$

Calculations for the Length:
$$\text{Sin}(55.01) = 1/c$$
$$c = 1/\sin(55.01)$$
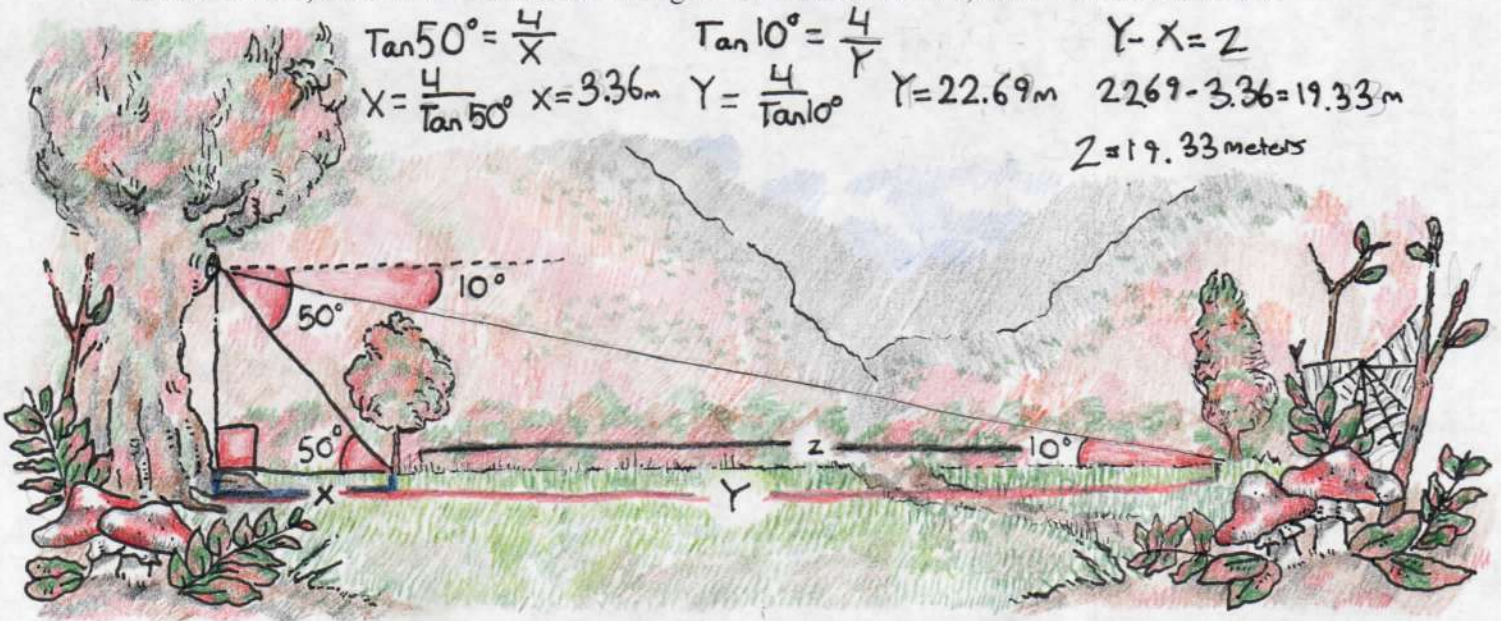$$c = 1.22 \text{ meters}$$

C

1 m

A

0.7m

On the leisurely walk towards Daisy's first job, she continued to quiz her daughter on the trigonometric functions. Every time that they crossed over a stile, or a wooden bridge, Daisy would stop briefly to find some key measurements and then Clover would make the calculations to find some unknown side or angle. It did not take much time for the sun to start shining with more intensity, and soon the day was warm and sunny. Between the stiles, Clover hummed softly as she pushed the surveyor's wheel down the lane, hearing it clack with every meter that they walked.

It was midday when Daisy Rabbit and Clover arrived at the cottage of Ms. Hawthorn. It was a small house built inside of the oak tree by the stone bridge. They knocked on the ivy-covered door and waited patiently. Daisy Rabbit needed to pay Ms. Hawthorn a visit as the field behind her cottage was to be the location of the Autumn Festival. It was a beautiful and shady spot where the forest grew to the edge of the river. Pale green branches of the weeping willows floated listlessly in the gentle breeze and the golden cowslips quivered upon their stalks. Ms. Hawthorn opened the door and guided them to her room.

In the bedroom, a window looked out upon the field. Daisy's job was to measure the field's width using a tree at the north of the field and a tree at the south. A creek flowed between them, making it impossible to measure with the wheel. Ms. Hawthorn informed Daisy that her window was exactly **4** meters above the flat ground. Then, Daisy Rabbit discovered that the angle of depression, or the angle with which she looked down upon the southern tree, was **50°** and the angle of depression looking upon the northern tree was **10°**. Clover, who wrote this down, labeled the distance between the cottage and the south tree as X, the distance between the cottage and the north tree as Y, and the field's width as Z.

$$\tan 50° = \frac{4}{X}$$
$$X = \frac{4}{\tan 50°} \quad X = 3.36m$$

$$\tan 10° = \frac{4}{Y}$$
$$Y = \frac{4}{\tan 10°} \quad Y = 22.69m$$

$$Y - X = Z$$
$$22.69 - 3.36 = 19.33m$$
$$Z = 19.33 \text{ meters}$$

Once Daisy Rabbit's calculations were complete, and she had found the width of the field between the northern tree and the southern tree, she and Clover said "Good bye" to Ms. Hawthorne and proceeded on their way. Ms. Hawthorne offered them tea and cakes, but they were forced to decline. They then went to the tall fir tree at the western edge of the field. It was very old, with patchy red bark that was peeled away in many places and spongy green moss climbing up its north side. It had only a few sparse branches at its top. "What will we do here?" asked Clover, picking up a pine cone at the base of the tree.

"Here we will hang the village's banner for the festival," Daisy Rabbit answered. The village always put a banner between two notches cut into the tree's side. This practice showed how much the tree grew over the past year, symbolizing the village's growth. "We'll find the distance between the notches, which will be the length of the banner." Clover found that Daisy stood **3.25** meters away from the base of the tree. From her perspective, Daisy found that the angle of elevation, or the angle with which she looked up at the highest notch, was **60°**, and the angle of elevation looking at the lower notch was **50°**. Clover labeled the lower notch's height as X, the higher notch's height as Y and the distance between them as Z.

$$\tan 50° = \frac{X}{3.25}$$
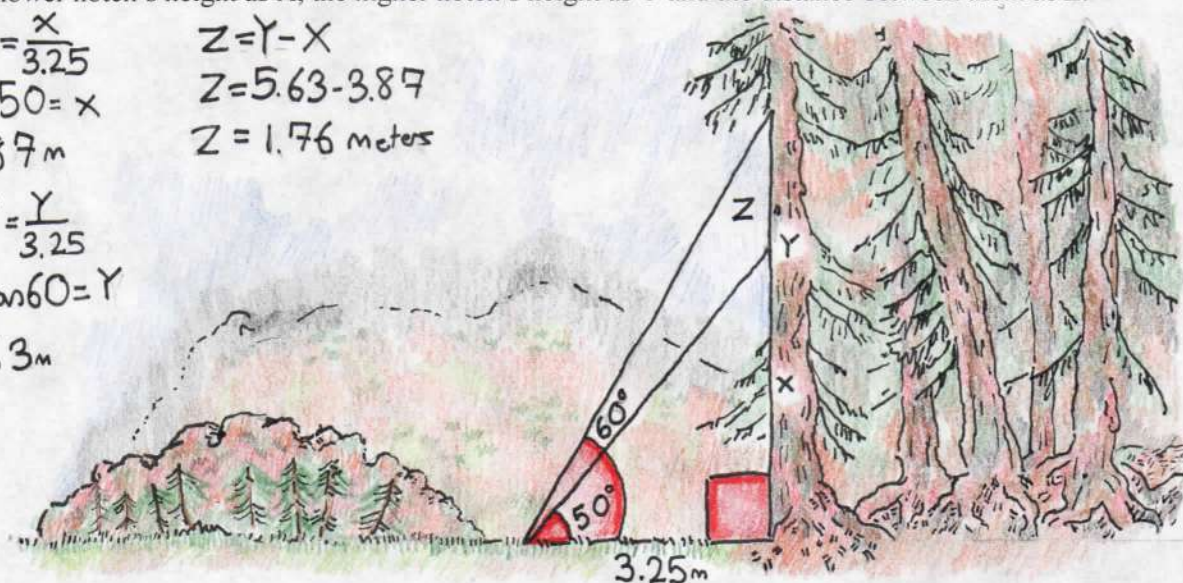$$3.25 \tan 50 = X$$
$$X = 3.87 m$$
$$\tan 60° = \frac{Y}{3.25}$$
$$3.25 \tan 60 = Y$$
$$Y = 5.63 m$$

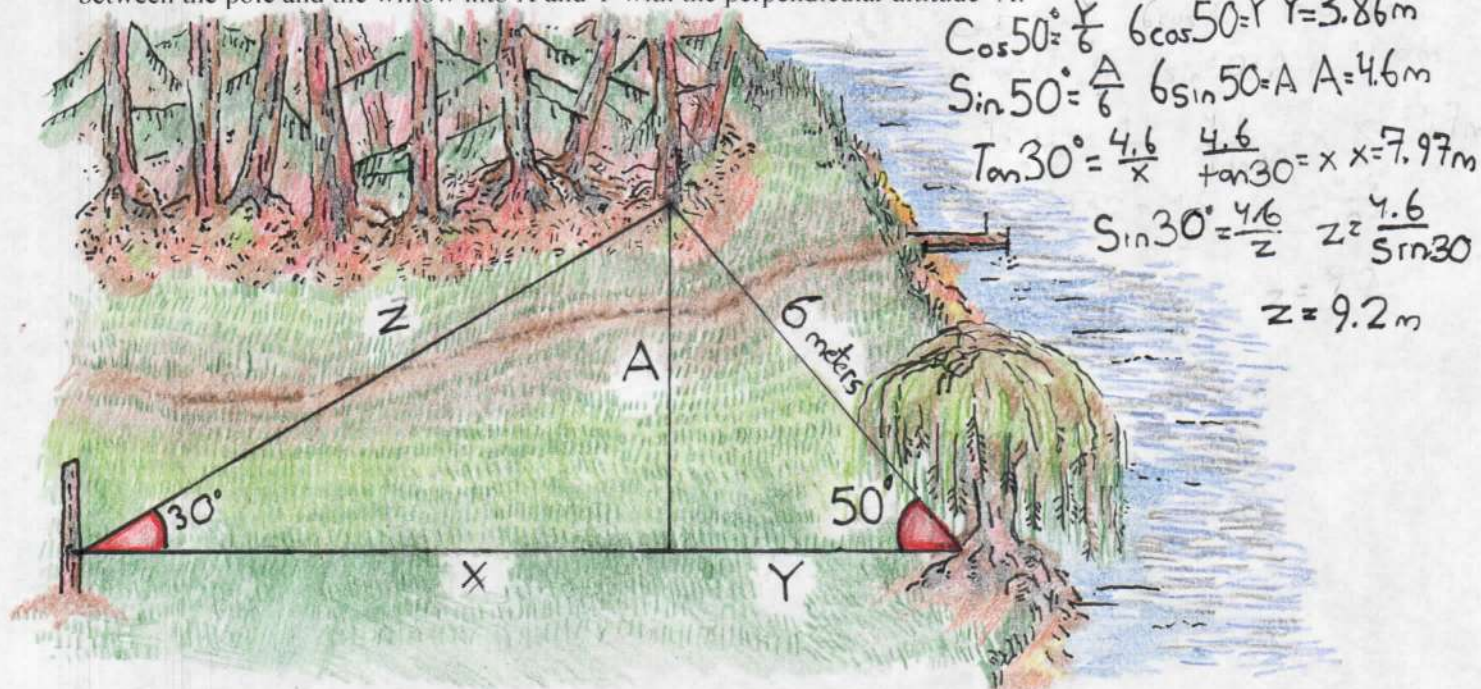$$Z = Y - X$$
$$Z = 5.63 - 3.87$$
$$Z = 1.76 \text{ meters}$$

3.25m

After completing her calculations at the fir tree, Daisy Rabbit and Clover ate upon a thick mat of soft red pine needles. The small wicker basket they brought was full of biscuits and bright red apples. As they ate, some villagers came up to them. "Good day," Daisy said. "Good day," Mr. Rivers said back, his voice carrying a sense of urgency. "We'd truly appreciate some help, Ms. Rabbit, if you'd not mind." Daisy was happy to oblige. At the northern tree, Mr. Rivers explained that they were trying to put rope in a triangle formation about the field so the children of the village could hang their pennants.

They planned on creating the triangle of rope by connecting the willow, the northern tree, and a wooden pole. "The distance between the willow and the northern tree is **6** meters," Mr. Rivers began, "we also know that the interior angle next to the pole is **30°** and the interior angle next to the willow tree is **50°**. Do you think you could you find the lengths of the other side?" Daisy was very willing to help, and decided to use this opportunity to show Clover how to find missing sides on a non-right triangle. Clover labeled the side connecting the pole and the northern tree as Z, and then was told to split the long side between the pole and the willow into X and Y with the perpendicular altitude 'A.'

$$\cos 50° = \frac{Y}{6} \quad 6\cos 50° = Y \quad Y = 3.86m$$

$$\sin 50° = \frac{A}{6} \quad 6\sin 50° = A \quad A = 4.6m$$

$$\tan 30° = \frac{4.6}{X} \quad \frac{4.6}{\tan 30} = X \quad X = 7.97m$$

$$\sin 30° = \frac{4.6}{Z} \quad Z = \frac{4.6}{\sin 30}$$
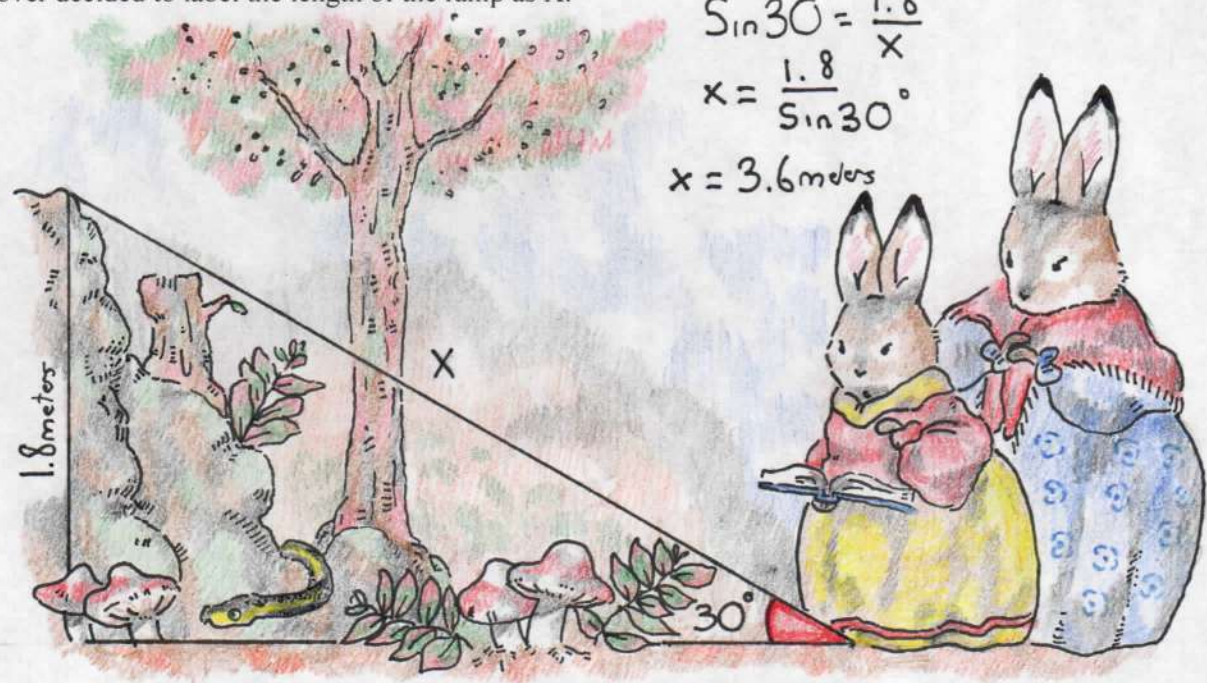
$$Z = 9.2m$$

Once they had finished helping Mr. Rivers and the other villagers with their calculations, Daisy Rabbit and Clover packed up the picnic which they had left by the tall fir tree and continued on their way towards the southern edge of the field. The hour had long since passed noon and already the shadows upon the clouds were becoming darker with a chill settling into the country air. Still, as they walked and pushed aside the tall grass, Daisy would stop to smell the tall pink foxgloves and the yellow cowslips while Clover gathered some small mushrooms in the basket.

When they arrived at the southern gate into the field, Daisy Rabbit explained to her daughter the task at hand. As a result of a general lack of activity in the area, the path which led down from the raised road and into the field itself had fallen into disrepair. It was overgrown and covered in fungus, scattered with rocks covered in moss. The carpenter wanted to build a ramp from the field to the road with an angle of elevation of **30°** from the perspective of the field. Daisy Rabbit's job was to find out how long a ramp would have to be to span from the edge of the road into the field if the height of the road was **1.8** meters. Clover decided to label the length of the ramp as X.
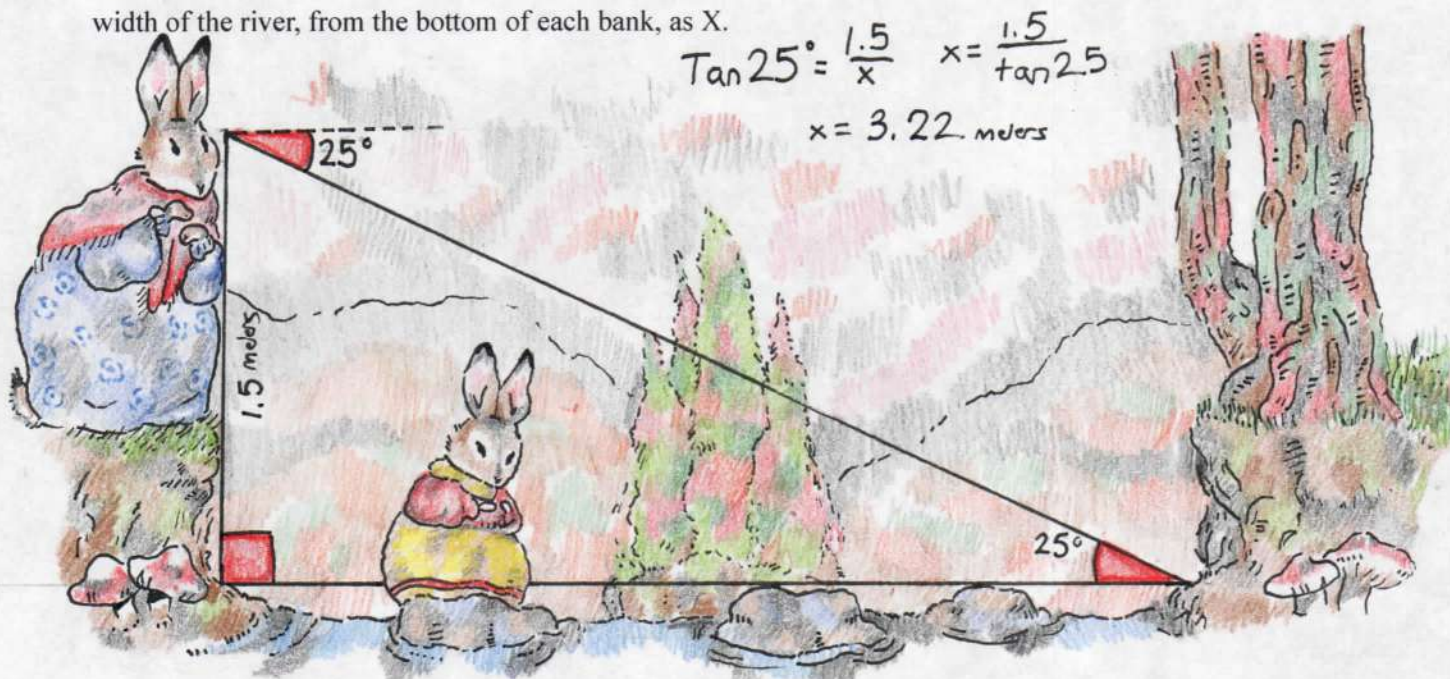
$$\sin 30° = \frac{1.8}{X}$$

$$X = \frac{1.8}{\sin 30°}$$

$$X = 3.6 \text{ meters}$$

After completing the calculations necessary for the carpenter to build a ramp at the south edge of the field, Daisy Rabbit and Clover found themselves walking towards their final destination of the day. Daisy was happy with the progress they had made in such a short amount of time. Clover felt that she had gotten a strong grasp of these trigonometric functions. The sky above them was beginning to turn a pink shade, with gold streaking through the clouds when they reached the bank of the river. There, Clover sat upon the soft grass of the bank among the reeds to relax briefly while Daisy explained the task at hand.

Daisy Rabbit explained that they had come to the western edge of the field in order to measure the width of the river. Because so many villagers would be arriving from the west, it was imperative that the hosts provided a wooden bridge for them to walk across with ease. The carpenter's apprentice had taken on this job, but she needed Daisy to get the measurements. Using her ruler, Daisy stood upon the top of the steep bank and found that her perspective was **1.5** meters above the water. She then found that the angle of depression with which she viewed the opposite edge of the river was **25°**. Clover labeled the width of the river, from the bottom of each bank, as X.

$$\tan 25° = \frac{1.5}{x} \qquad x = \frac{1.5}{\tan 25}$$

$$x = 3.22 \text{ meters}$$

Once Daisy Rabbit and Clover had at last completed the calculations required for the bridge over the river by the meadow, they were finally able to return home. Golden light still lingered ever so slightly over the countryside, but the darkness of the night was beginning to fall. In the distance, beyond the wood, an owl called out into the cold air. The thicket quivered softly as the wind grew in force, whistling through the leaves and tall grasses. The trees grew dark, and all the light but that from the pale moon was extinguished from the forest floor. However, Daisy and her daughter were unafraid. They walked for a while, taking in the cool, night air before reaching the thicket where their cottage lay.

At long last, Daisy Rabbit and Clover arrived at their cottage. When they opened the door, sweet golden light poured out onto the floor and they felt the warmth of the fire upon their faces. Ivy and the sitter were sitting by the stove but stood up quickly to greet them. The wonderful smell of hot stew and freshly baked bread wafted over to them. It was a beautiful night, and it had been a wonderful day, but now they were tired and all too ready for bed.

Only a week after Daisy Rabbit and Clover had completed their calculations, the Autumn Festival was entirely set up. The village carpenters had been hard at work, constructing the bridge over the river and the ramp down from the road so that the meadow would be as accessible as possible. Long tables were covered in linen and laden high with freshly baked breads and pies. There were plates of cheese and bowls of hot soup. The feast's sweet aroma wafted over field on a gentle breeze which caused the banner high in the tall fir tree to flutter. Everyone in the surrounding fields had arrived in their best clothes.

Ivy and Clover spent their day with the other children of the village, engaging with the activities set up to celebrate the good harvest. There was a stand filled with bright red apples which they could dip in sweet honey and sugar, but Clover had to hold Ivy's as she kept getting her paws sticky. There was a table covered in vegetables that were submitted by the village gardeners for a variety of awards. Ivy found herself marvelling at the largest pumpkin, which seemed big enough to live in. Clover's favorite activity, however, was the very last one. As the sky darkened and the festival began coming to a close, all the children got into a carriage filled with hay and watched as the orange countryside flew by them.

There's an Autumn Festival coming to celebrate the harvest. Daisy Rabbit and her daughter, Clover, will use their prowess in trigonometric functions to make sure the festival goes smoothly.