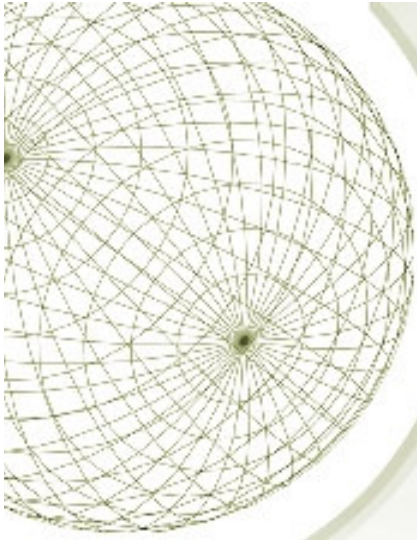
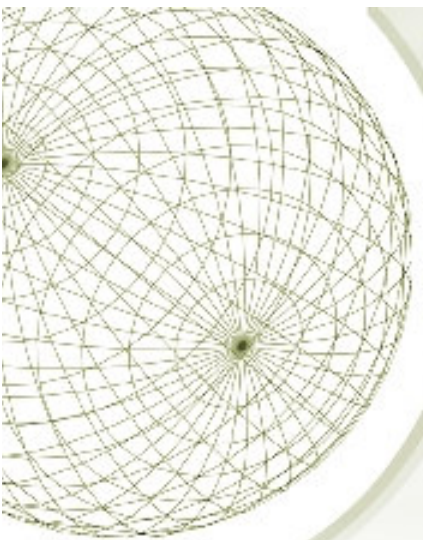




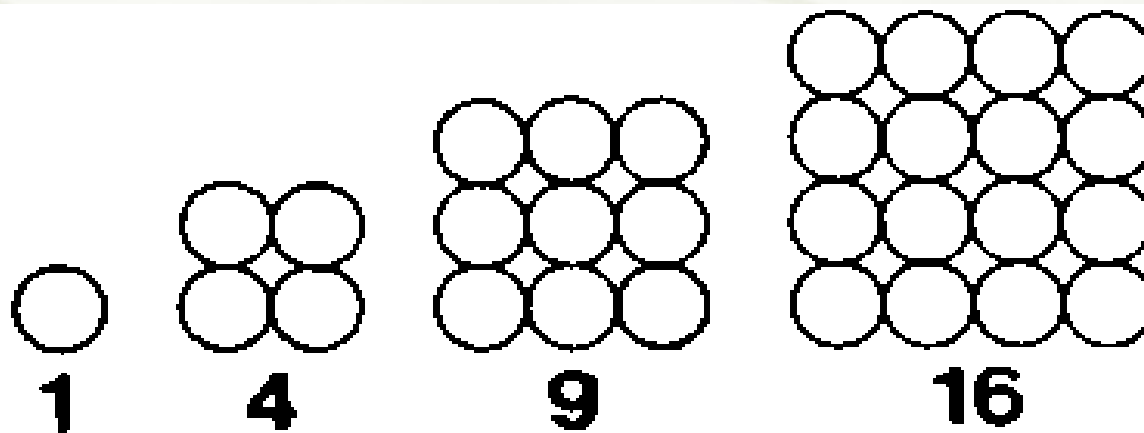
Squares & Square Roots

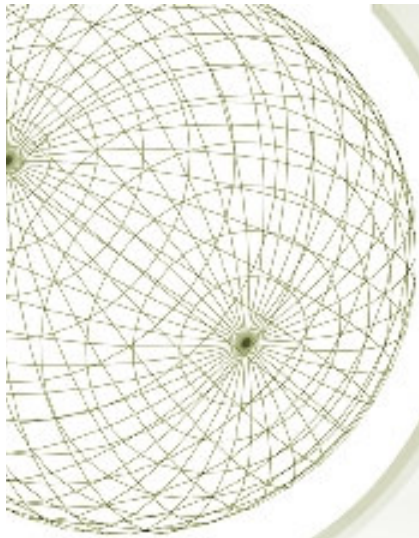
Perfect Squares



Square Number

- ✦ Also called a “*perfect square*”
- ✦ A number that is the square of a whole number
- ✦ Can be represented by arranging objects in a square.

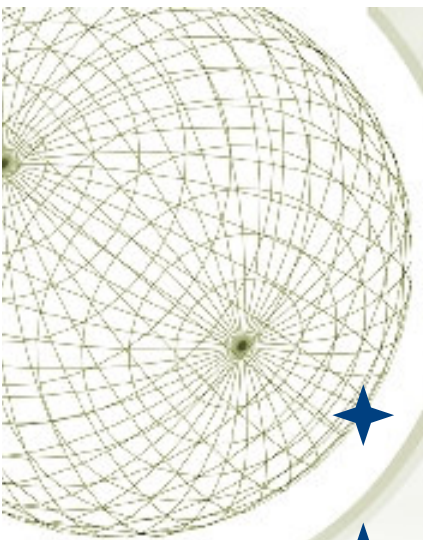




Square Numbers

MULTIPLICATION TABLE

	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9
2	2	4	6	8	10	12	14	16	18
3	3	6	9	12	15	18	21	24	27
4	4	8	12	16	20	24	28	32	36
5	5	10	15	20	25	30	35	40	45
6	6	12	18	24	30	36	42	48	54
7	7	14	21	28	35	42	49	56	63
8	8	16	24	32	40	48	56	64	72
9	9	18	27	36	45	54	63	72	81



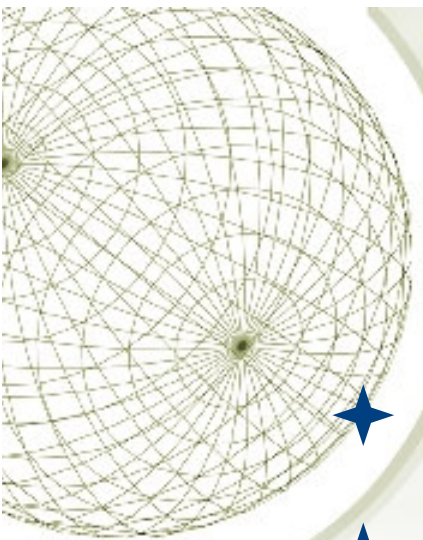
Square Numbers

★ $1 \times 1 = 1$

★ $2 \times 2 = 4$

★ $3 \times 3 = 9$

★ $4 \times 4 = 16$



Square Numbers

★ $1 \times 1 = 1$

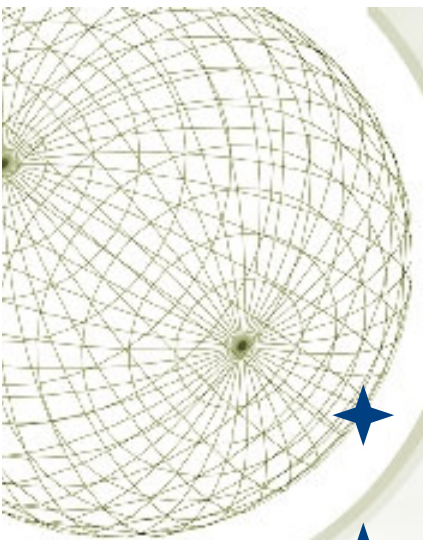
★ $2 \times 2 = 4$

★ $3 \times 3 = 9$

★ $4 \times 4 = 16$

Activity:

Calculate the perfect squares up to 15^2 ...



Perfect Squares

$$\star 1 \times 1 = 1$$

$$\star 2 \times 2 = 4$$

$$\star 3 \times 3 = 9$$

$$\star 4 \times 4 = 16$$

$$\star 5 \times 5 = 25$$

$$\star 6 \times 6 = 36$$

$$\star 7 \times 7 = 49$$

$$\star 8 \times 8 = 64$$

$$\star 9 \times 9 = 81$$

$$\star 10 \times 10 = 100$$

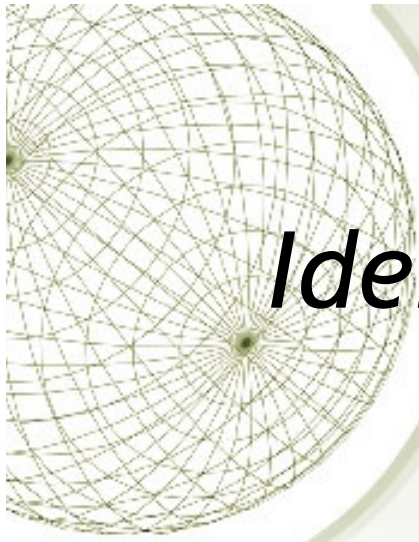
$$\star 11 \times 11 = 121$$

$$\star 12 \times 12 = 144$$

$$\star 13 \times 13 = 169$$

$$\star 14 \times 14 = 196$$

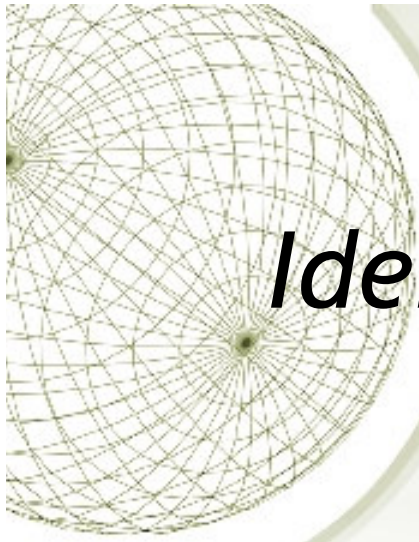
$$\star 15 \times 15 = 225$$



Activity:

Identify the following numbers as perfect squares or not.

- i. 16**
- ii. 15**
- iii. 146**
- iv. 300**
- v. 324**
- vi. 729**



Activity:

Identify the following numbers as perfect squares or not.

i. $16 = 4 \times 4$

ii. ~~15~~

iii. ~~146~~

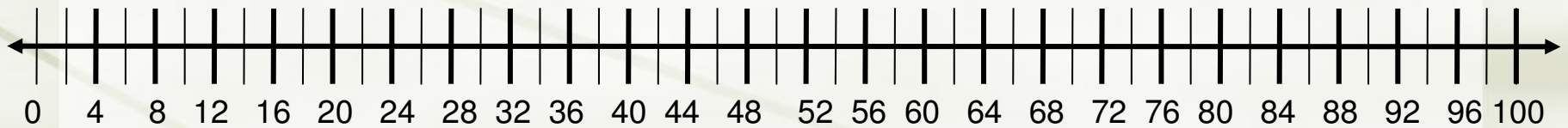
iv. ~~300~~

v. $324 = 18 \times 18$

vi. $729 = 27 \times 27$

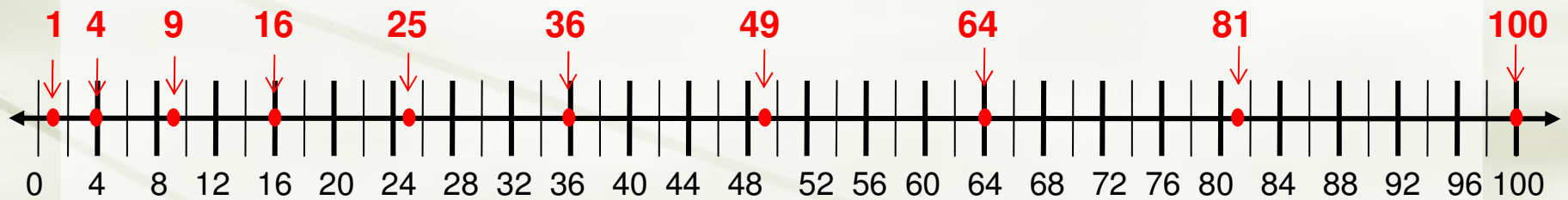
Activity:

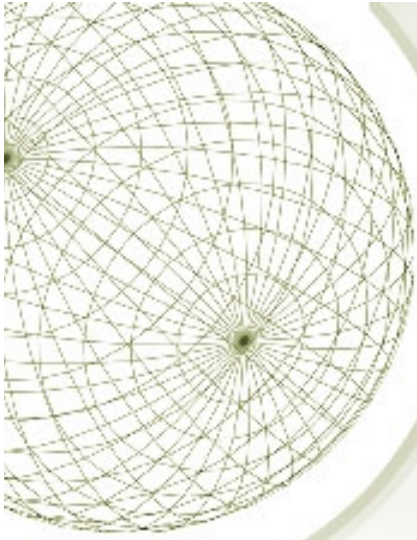
Graph the perfect squares between 1 and 100 on a number line.



Activity:

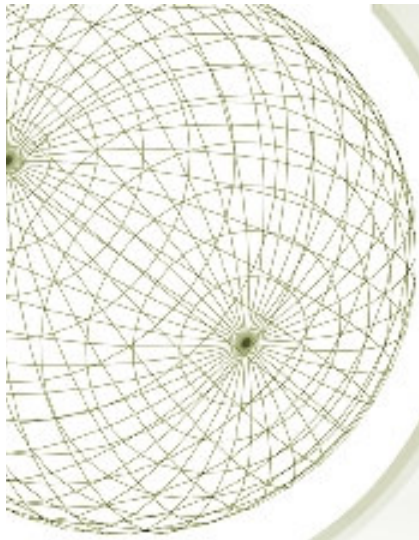
Graph the perfect squares between 1 and 100 on a number line.





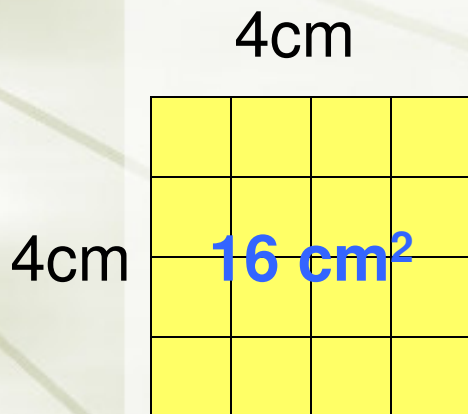
Squares & Square Roots

Square Root



Square Numbers

★ One property of a perfect square is that it can be represented by a square array.

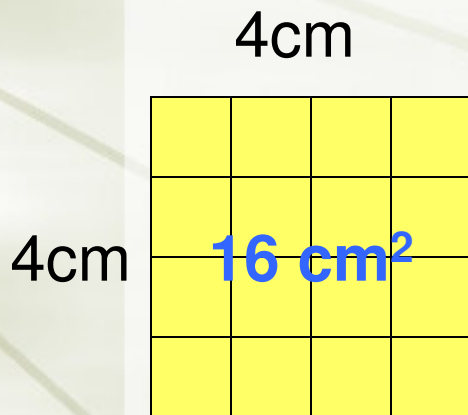


★ Each small square in the array shown has a side length of 1cm.

★ The large square has a side length of 4 cm.

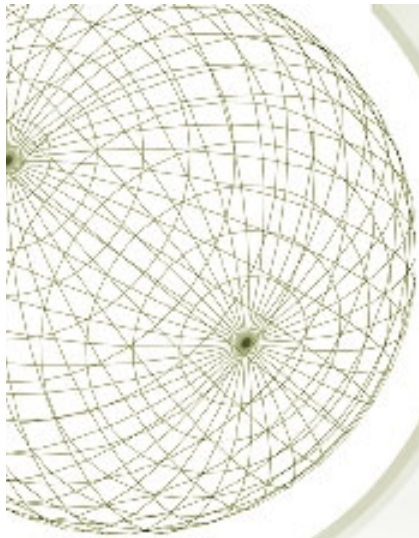
Square Numbers

✦ The large square has an area of $4\text{cm} \times 4\text{cm} = 16\text{ cm}^2$.



✦ The number 4 is called the square root of 16.

✦ We write: $4 = \sqrt{16}$

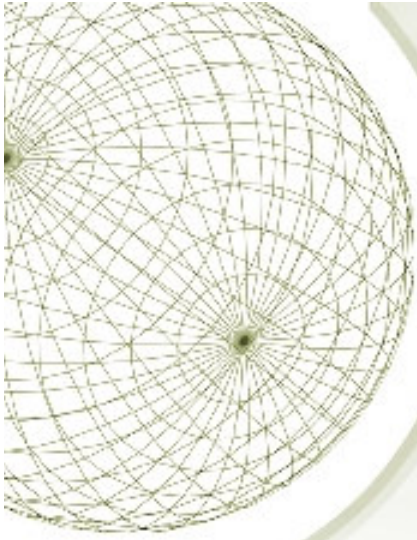


Square Root

✦ A number which, when multiplied by itself, results in another number.

✦ Ex: 5 is the square root of 25.

$$5 = \sqrt{25}$$



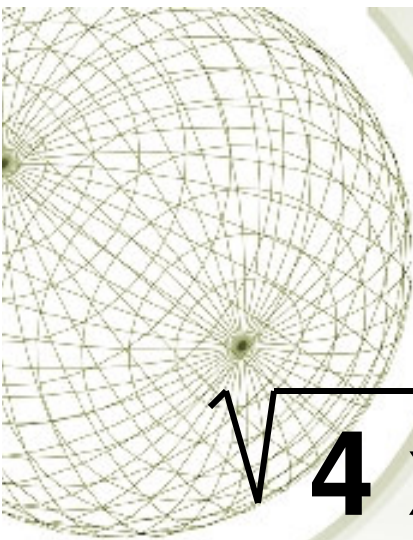
Finding Square Roots

✦ We can use the following strategy to find a square root of a large number.

$$\sqrt{4 \times 9} = \sqrt{4} \times \sqrt{9}$$

$$\sqrt{36} = 2 \times 3$$

$$6 = 6$$



Finding Square Roots

$$\sqrt{4 \times 9} = \sqrt{4} \sqrt{9}$$

$$\sqrt{36} = 2 \times 3$$

$$6 = 6$$

★ We can factor large perfect squares into smaller perfect squares to simplify.



Finding Square Roots

★ ***Activity: Find the square root of 225***

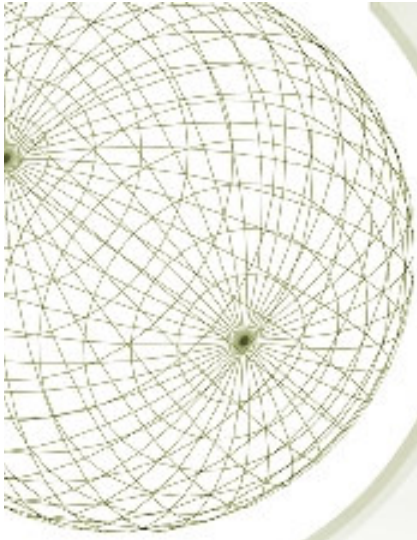
★ *If you didn't know that 225 was a perfect square, you would first see if 225 has any factors that are perfect squares. You know 25 goes into 225 so try that.*

$$\sqrt{225} = \sqrt{25 \times 9}$$

$$= \sqrt{25} \times \sqrt{9}$$

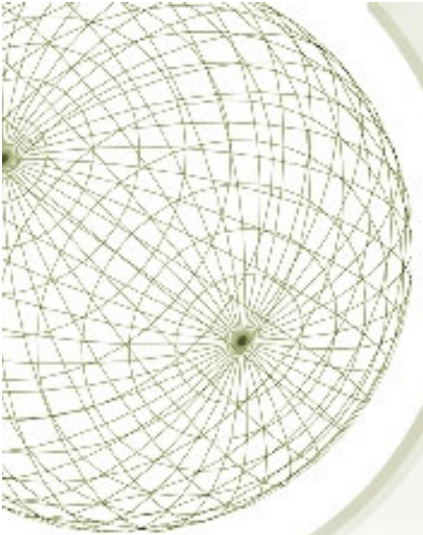
$$= 5 \times 3$$

$$= 15$$



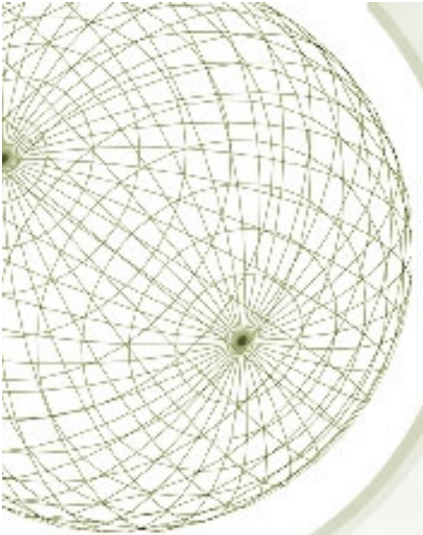
Squares & Square Roots

Estimating Square Root



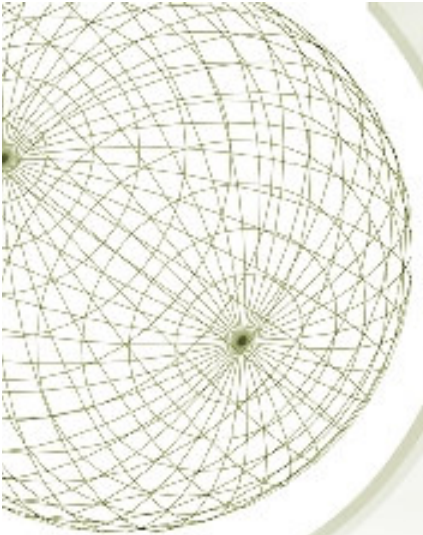
Estimating Square Roots

$$\sqrt{25} = ?$$



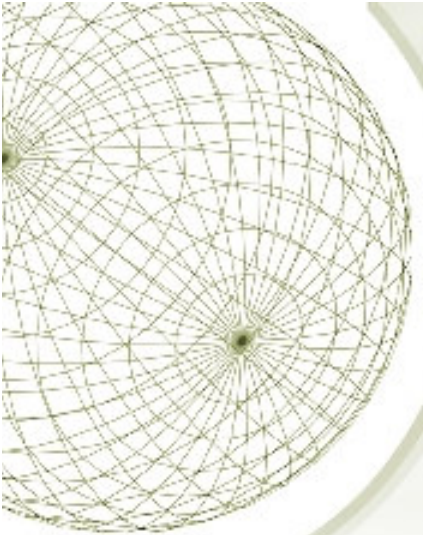
Estimating Square Roots

$$\sqrt{25} = 5$$



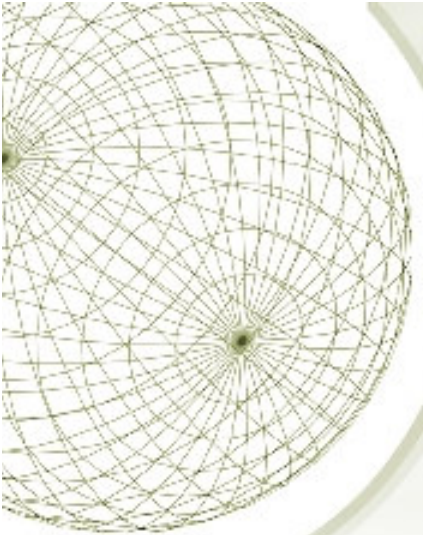
Estimating Square Roots

$$\sqrt{49} = ?$$



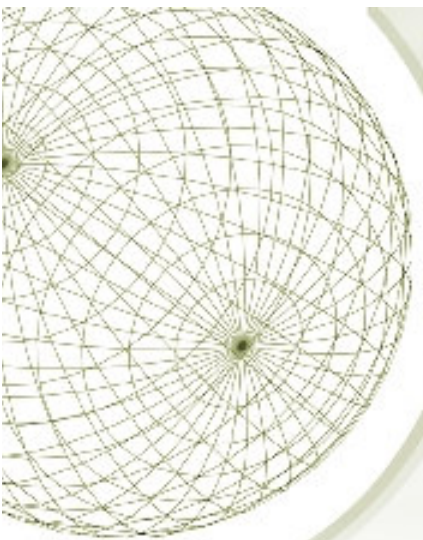
Estimating Square Roots

$$\sqrt{49} = 7$$



Estimating Square Roots

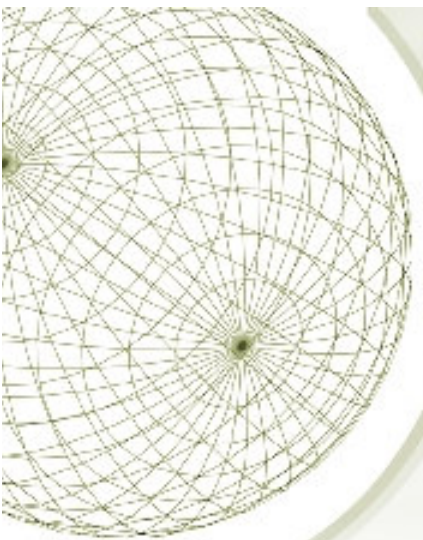
$$\sqrt{27} = ?$$



Estimating Square Roots

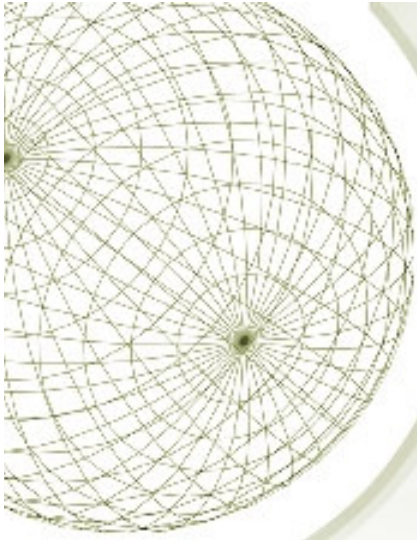
$$\sqrt{27} = ?$$

Since 27 is not a perfect square, we have to use another method to calculate it's square root.



Estimating Square Roots

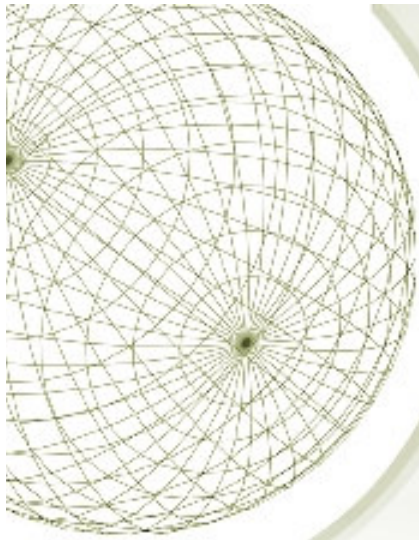
- ✦ Not all numbers are perfect squares.
- ✦ Not every number has an Integer for a square root.
- ✦ We have to estimate square roots for numbers between perfect squares.



Estimating Square Roots

✦ To calculate the square root of a non-perfect square

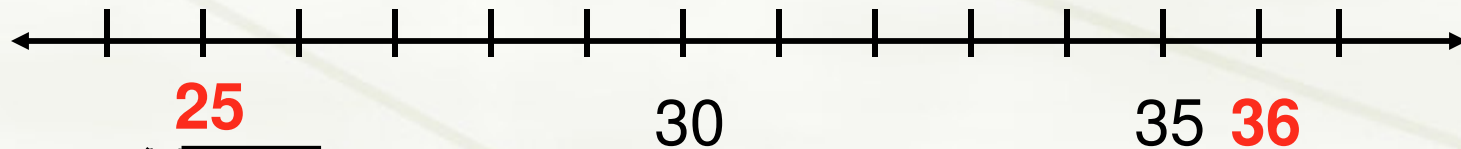
1. Place the values of the adjacent perfect squares on a number line.
2. Interpolate between the points to estimate to the nearest tenth.



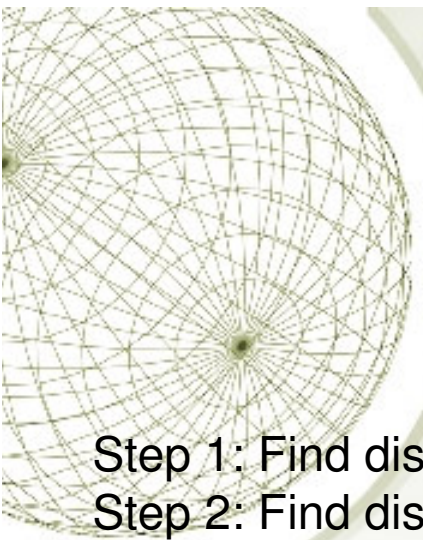
Estimating Square Roots

★ Example: $\sqrt{27}$

What are the perfect squares on each side of 27?



So $\sqrt{27}$ is going to be somewhere between $\sqrt{25}$ and $\sqrt{36}$ or more specifically, between 5 and 6.



Estimating Square Roots

✦ **Example:** $\sqrt{27}$

Step 1: Find distance between nearest perfect squares to 27: $36 - 25 = 11$

Step 2: Find distance between the “non-perfect-square” number smaller perfect square:

$$27 - 25 = 2$$

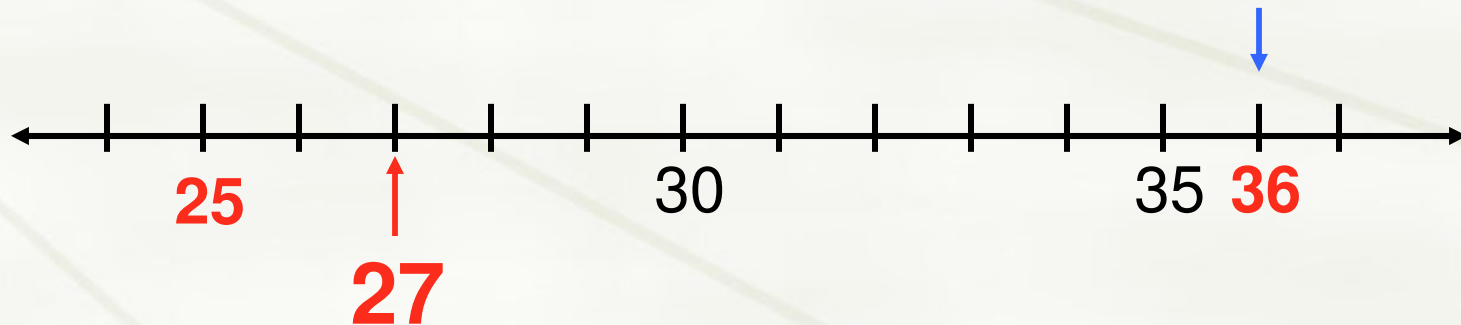
Step 3: Divide answer to Step 2 by answer to Step 1: $2/11 \approx .2$

Step 4: Add answer to Step 3 to the Square Root of the smaller perfect square.

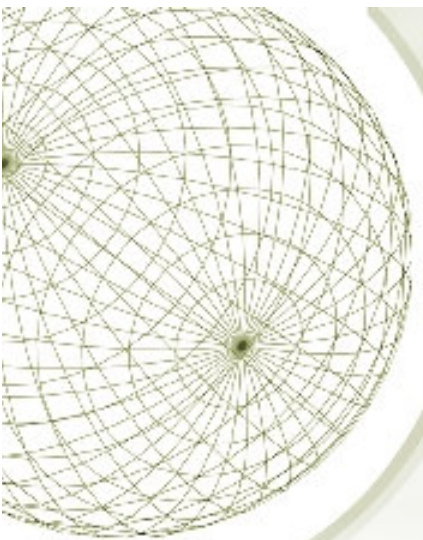
27 is 2 tenths the distance from 25 to 36.

$\sqrt{27}$ is going to be 2 tenths from $\sqrt{25}$ to $\sqrt{36}$, (from 5 to 6).

Add .2 to 5 and get 5.2 is 2 tenths the distance from 5 to 6.



Estimate $\sqrt{27} \approx 5.2$

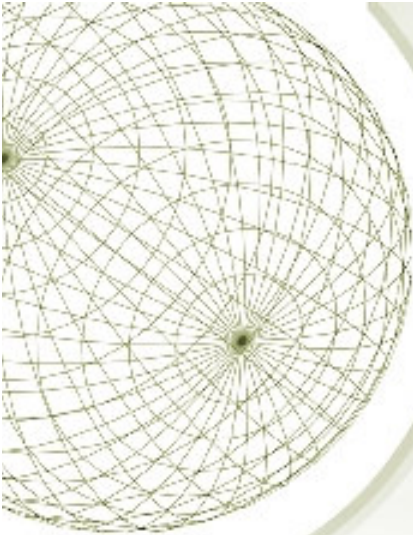


Estimating Square Roots

★ Example: $\sqrt{27}$

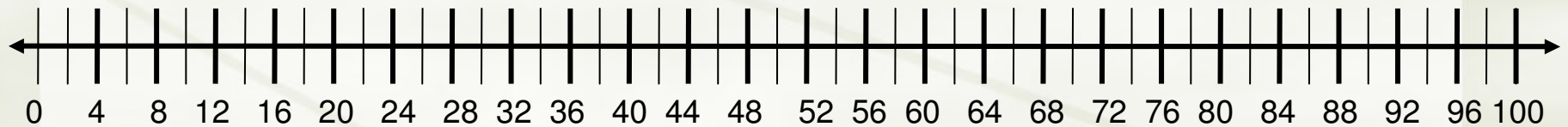
★ Estimate: $\sqrt{27} \approx 5.2$

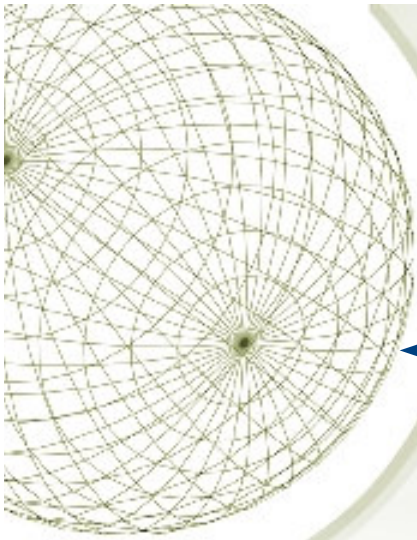
★ Check: $(5.2)(5.2) = 27.04$



Estimating Square Roots

★ Example: $\sqrt{18}$





Square Root Properties

★ **The square root of a negative number is NOT a real number.**

❖ **Why? Because by definition**

If $b = \sqrt{a}$, then $b^2 = a$.

There is no real number that, when squared, gives a negative number.

Example : $\sqrt{-81}$, $\sqrt{-16}$, $\sqrt{-3}$ are NOT real numbers.

❖ **Negative Signs can be applied after taking the square root.**

$-\sqrt{25}$ is a real number though, because you take the square root first, then apply the negative sign.

$$-\sqrt{25} = -5$$

❖ **Treat Radical Signs (Square Roots) as Special Grouping Symbols (in PEMDAS)**

$$\sqrt{16+9} = \sqrt{25} = 5$$

$$\sqrt{16} + \sqrt{9} = 4 + 3 = 7$$

Do what's inside the radical sign first.



Order of Operations with Square Roots

Make sure you follow PEMDAS

Treat the Radical Sign as a special grouping symbol.

Example:

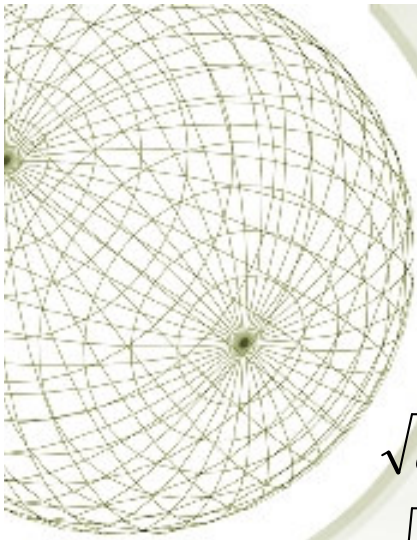
$$-6\sqrt{81} + 5\sqrt{1}$$

Do what's inside the "grouping symbols" first.

$$= -6(9) + 5(1)$$

$$= -54 + 5$$

$$= -49$$



Square Root Properties

★ For all non-negative numbers, a and b :

$$\sqrt{a^2 \cdot b^2} = a \cdot b$$

$$\sqrt{\frac{a^2}{b^2}} = \frac{\sqrt{a^2}}{\sqrt{b^2}} = \frac{a}{b}$$

Example 1:

$$\begin{aligned} &\sqrt{\frac{25}{64}} \\ &= \frac{\sqrt{25}}{\sqrt{64}} \\ &= \frac{5}{8} \end{aligned}$$

Notice that 25 and 64 are both perfect squares!

Example 2: Convert Decimals to Fractions to easily see the perfect squares inside them.

$$\sqrt{.81} = \sqrt{\frac{81}{100}} = \frac{\sqrt{81}}{\sqrt{100}} = \frac{9}{10} = .9$$

$$\sqrt{1.69} = \sqrt{\frac{169}{100}} = \frac{\sqrt{169}}{\sqrt{100}} = \frac{13}{10} = 1.3$$