**My name is Simon Njeru Mugoh.**

**Welcome to CEMASTEA Mathematics Tutorial Session, in this Session we will explain ‘Rules of Indices’**

Indices is the plural of index

What is an index?

Index tells us how many times you have to multiply the number by itself.

It is also referred to as the power.

For example: 2x2x2x2x2=32

This can also be written as 2x2x2x2x2=2 power 5, where 5 is the index and 2 is the base. This means that 2 has been multiplied by itself 5 times.

**An application on index form and expanded form of a number**

1st let us differentiate between the expanded form and index form of a number

In the 1st Example **5x5x5x5 =5 power 4**, we are converting from expanded form to index form.

In the 2nd Example, try to do it by yourself, convert the expanded form of **8x8x8x8x8x8x8** into index form. Here 8 has been multiplied by itself 7 times and hence written as **8 power 7** in index form.

In the 3rd Example we are converting from index form to expanded form **3 power 4** which means that 3 is multiplied by itself 4 times. Hence in expanded form we have **3×3×3×3**.

Try to do the 4th example by your own where you are given **23 power 3**. Here it means that 23 is going to be multiplied by itself 3 times. Hence in expanded form we have **23×23×23.**

**Practice:** Complete the table below – (take 3 min to complete the table, you may pause the video for 3 min)

**In Part a**, the expanded form is 7x7x7x7x7 while the index form is **7 power 5**

**In Part b**, the index form is 31 power 4, which means 31 is multiplied by itself 4 times, then the expanded form is **31x31x31x31**

**In Part c,** the expanded form is 2x2x2x2x2x2 then the index form is **2 power 6**

**Laws of Indices**

In this lesson we are going to look at the 1st 3 laws of indices. These are

1. Law of multiplication also referred to as the ‘product law’
2. Law of division also referred to as the ‘quotient law’
3. Distributive law

The other remaining laws will be covered in the 2nd lesson

1. **Investigating Law of Multiplication**

Take the Example: - **2 power 3** multiplied by **2 power 6** the answer is 2 power 9. The reason is 2 power 3 means 2 is multiplied by itself 3 times while 2 power 6 means 2 is multiplied by itself 6 times. In total, 2 is multiplied by itself 9 times which means 2 power 9. Therefore 2 power 3 multiplied by 2 power 6 is equal to 2 power 9.

**Please complete the table below - take 5 min (you can pause the video for 5 min)**

1st write each term in the expanded form then convert it to index form. The table has 2 columns, one for ‘**Expanded form**’ & the other for ‘**Index form**’.

**In Part a,** you are given 5 power 3 multiplied by 5 power 2. 5 power 3 means that 5 is multiplied by itself 3 times while 5 power 2 means that 5 is multiplied by itself 2 times. In total 5 is multiplied by itself 5 times which means 5 power 5. Therefore 5 power 3 multiplied by 5 power 2 is equal to 5 power 5.

**In Part b,** you are given 3 power 4 multiplied by 3 power 2. 3 power 4 means that 3 is multiplied by itself 4 times while 3 power 2 means that 3 is multiplied by itself 2 times. In total 3 is multiplied by itself 6 times which means 3 power 6. Therefore 3 power 4 multiplied by 3 power 2 is equal to 3 power 6.

**In Part c,** you are given 2 power 4 multiplied by 2 power 5. 2 power 4 means that 2 is multiplied by itself 4 times while 2 power 5 means that 2 is multiplied by itself 5 times. In total 2 is multiplied by itself 9 times which means 2 power 9. Therefore 2 power 4 multiplied by 2 power 5 is equal to 2 power 9.

* What can you conclude when multiplying numbers with same base? (Take 1 min to think about it)

When multiplying numbers with same base write the base and add the powers. Thus, the 1st rule regarding law of multiplication is defined by **a power m** multiplied by **a power n** is equal to **a power (m+n)**.

1. **Investigating Law of Division**

In this section we will investigate the law of division by taking the example having **2 power 3** divided by **2 power 2** which can be written as 2 power 3 over 2 power 2 the answer in index form is **2 power 1**.

In order to understand more on how to find the result of division, complete the table below using the following direction:-

1st Step: - Write each term in expanded form,

2nd Step: - Simplify the fraction,

3rd Step: - Check how many times the term is repeated, then

4th Step: - Write the term in index form.

**In Part a,** you are given 5 power 3 divided by 5 power 2. 5 power 3 will be in the numerator and 5 power 2 will be in the denominator. Now expand 5 power 3 and 5 power 2 and simplify. The result of simplification is 5 over 1 which is equal to 5. This means that 5 is multiplied by itself 1 time which means 5 power 1 in index form. Therefore 5 power 3 divided by 5 power 2 is equal to 5 power 1.

**In Part b,** you are given 3 power 4 divided by 3 power 2. 3 power 4 will be in the numerator and 3 power 2 will be in the denominator. Now expand 3 power 4 and 3 power 2 and simplify. The result of simplification is 3 x 3 over 1 which is equal to 3 x 3. This means 3 is multiplied by itself 2 times which means 3 power 2. Therefore 3 power 4 divided by 3 power 2 is equal to 3 power 2.

**In Part c,** you are given 2 power 4 divided by 2 power 5. 2 power 4 will be in the numerator while 2 power 5 will be in the denominator. Now expand 2 power 4 and 2 power 5 and simplify. The result of simplification is 1 over 2. This means the 2 in the denominator is multiplied by itself 1 time which means 1 over 2 power 1 which is the same as 2 power negative 1. Therefore 2 power 4 divided by 2 power 5 is equal to 2 power -1.

* What can you conclude when dividing numbers with same base? (Take 1 min to think about it)

When dividing numbers with same base write the base and subtract the powers. Thus, the 2nd rule regarding law of division is defined by **a power m** divided by **a power n** is equal to **a power (m-n)**.

1. **Investigating Distributive Law**

In this section we will use the prime factorization method in order to deduce the distributive law.

Please complete the table below and follow the steps of **Part a** where we have **6 power 3**.

1st expand the term 6 power 3 into 6 × 6 × 6. Then find the prime factorization of the base 6 which is 2 × 3. Replace 6 with 3 × 2, the prime factorization of the base in the expanded form – here we have 2 × 3 × 2 × 3 × 2 × 3. Combine the like terms as follows, 2 × 2 × 2 × 3 × 3 × 3 and then write the answer in index form, 2 power 3 multiplied by 3 power 3.

**In Part b**, the expanded form of 12 power 2 is 12 x 12 and the prime factorization of the base 12 is 2 power 2 multiplied by 3, after finding the prime factorization replace it’s result in the expanded form. Thus we get 2 power 2 multiplied by 3, 2 times. That is 2 power 2×3×2 power 2×3. You now combine like terms and write in index form the answer of 12 power 2 which is equal to 2 power 4 multiplied by 3 power 2.

**In Part c**, the expanded form of 10 power 4 is 10 x 10 x 10 x 10 and the prime factorization of 10 is 2 x 5, now replace the result of prime factorization in the expanded form and combine like terms, the result will be as follows 2 x 2 x 2 x 2 x 5 x 5 x 5 x 5. This can now be written in index form as 2 power 4 multiplied by 5 power 4.

* What can you conclude of a composite number raised to a power? A composite number can be expressed into prime factors? (Take 1 min to think about it)

A composite number **m** can be expressed as a prime factorization **a×b.** Thus, the 3rd rule, the ‘distributive law’ is defined by a number **m power n** which is equal **(a×b)n** and equal to **an × bn**.

In this section we will use **CASIO fx-82EX**, a non-programmable Calculator to investigate faster the three laws of indices. Let’s deduce the three laws of indices;-

**1) Law of Multiplication**

**Consider, 2 power 3 multiplied by 2 power 6.**

1st turn on the Calculator and click Menu to get 1: Calculate. Press AC to activate the calculation mode. Type the numerical expression by typing 2, then press the x power icon and type 3, then press the right arrow and press multiplication sign then type 2 then press x power icon and type 6 then press =. The Calculator will show a 512. To convert to index form press shift then minutes seconds key (Shift key activates yellow function). The result will appear as an index form, 2 power 9.

**2) Law of Division**

**Consider 3 power 9 divided by 3 power 3.**

Press AC then type the expression in Calculator by pressing 3 then the x power icon and press 9, then press right arrow to move out from the power space then press division key and press 3, then the x power icon and press 3, then press =. The Calculator will show 729. To convert to index form press shift then minutes seconds key. The result will appear as an index form, 3 power 6.

**3) Distributive Law**

**Consider 6 power 12.**

We will do the same steps which you can now try by yourself. Type the numerical expression by pressing 6, then x power icon and type 12. You will get a big number, 2,176,782,336. To covert to index form press shift then minutes seconds key. The result will appear as an index form 2 power 12 multiplied by 3 power 12.

Please check the assignment given below so that you practice further what we have learnt today.

**Question 1**: Explain how the knowledge of indices can be applied in real life situation

**Question 2**: Deduce the laws of indices in each case

1. 52 × 58
2. 68
3. 712 ÷ 78

**Thank you very much!**