

MATHEMATICS (USING A CALCULATOR) FOR RADIO AMATEURS & ELECTRONICS

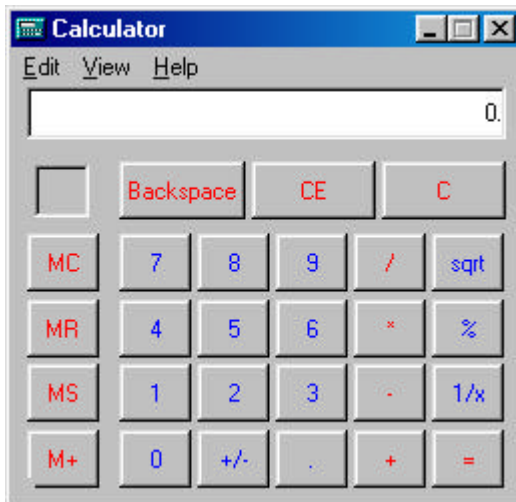
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<http://w3.to/ronb>

In all amateur theory examinations you are allowed to use a calculator and a pen and paper for calculations. The purpose of this reading is to help you become familiar with a calculator. For our purposes we will be using the calculator that comes built into Windows 95/98.

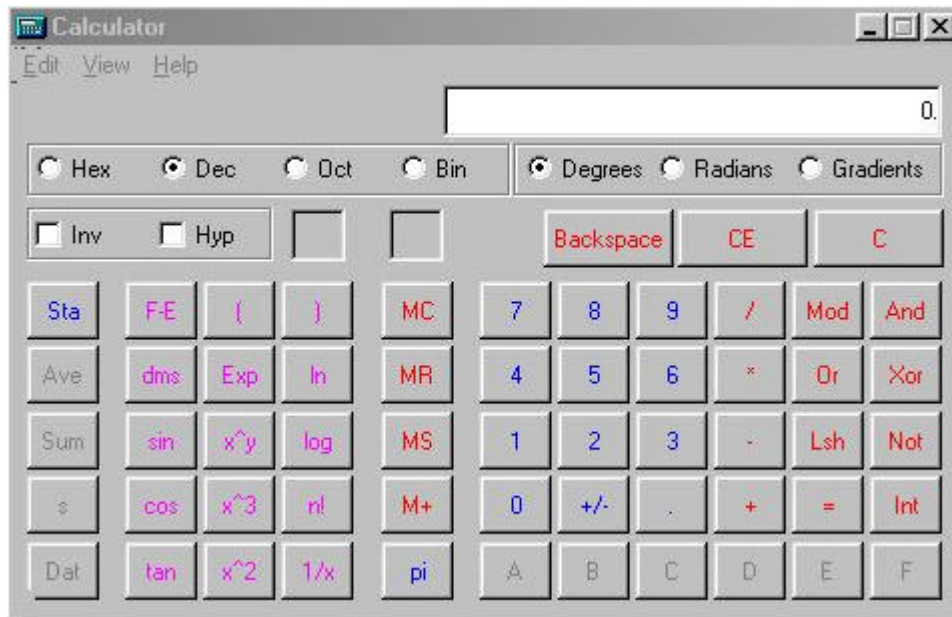
Most purchased calculators work the same as the Windows calculator with the exception of some that use the RPN (reverse polish notation) these calculators are popular with some engineers however I strongly suggest you do not purchase one of these. A simple inexpensive high school calculator is more than you will need.

This is what the windows calculator looks like.



This is the standard view of the calculator. In this view there are no scientific functions, to be really useful we need these scientific functions. To get them click on "VIEW" and then select "SCIENTIFIC" The calculator will then explode to the full view shown below.

In the scientific view there are more functions than you will require in any amateur radio examination. We will do some calculations using equations and problems you may come across in this course and in the examination. Generally speaking the level of maths is higher in the course than you can expect in the exam and this is only done for the purpose of understanding.



One the most important keys to understand first off is the key labelled EXP



Exp is short for exponent. Lets take 1,000,000 metres. We normally call this distance a 1000 kilometres. We use scientific notation to make it easier to right down very big or very small numbers.

We could write 1,000,000 (one million) metres as:

$$1 \times 10^6 \text{ metres}$$

The '6' is called the exponent, an exponent of 6 means we must move the decimal place 6 places to the RIGHT to return the number to 'normal'. The decimal place is not shown, though we know that it is just to the right of the 1.

We could have written 1,000,000 kilometres this way

1.0 $\times 10^6$ metres - this is exactly the same thing except now you can see the position of the decimal place.

So if you take 1.0 and move the decimal place 6 places to the right you get 1000000 or 1,000,000 you should see that 1×10^6 is easier to write down.

Take 1/1000,000 or 1 millionth. This is written in scientific notation as 1×10^{-6}

This time the exponent is -6 which means "move the decimal place 6 places to the left. If we do this we get .000001 - it is customary to place an 0 in front of the decimal point to make it a little easier to read so 1×10^{-6} is 0.000001

The reason we need to use exponent is because we of the units we use in radio and electronics.

gig	= 1,000,000,000 =	10^9
meg	= 1,000,000 =	10^6
kilo	= 1,000 =	10^3
Units		
milli	= 1/1000 =	10^{-3}
micro	= 1/1,000,000 =	10^{-6}
nano	= 1/1,000,000,000	10^{-9}
pico	= 1/1,000,000,000,000 =	10^{-12}

Notice that all of the common units are multiples of exponent 3. When you do calculations you always have to enter the base unit into the calculator unless told otherwise. For example take the formula derived from Ohms law.

$$I = E/R$$

Current equal voltage divided by resistance. I is in amperes; E volts and R Ohms. This is fine if you are given the voltage and the resistance in base units. What if you are given: -

$$E = 25 \text{ microvolts}$$
$$R = 50 \text{ milliohms}$$

To enter this into the calculator and do the division E/R you would enter

$$25 \text{ microvolts} = 25 \times 10^{-6}$$

$$50 \text{ milliohms} = 50 \times 10^{-3}$$

Let's see how we would enter these two numbers into the calculator and divide them to get the current in amperes.

$$I = 25 \times 10^{-6} / 50 \times 10^{-3}$$

first 25 uV (microvolts)

Press 2

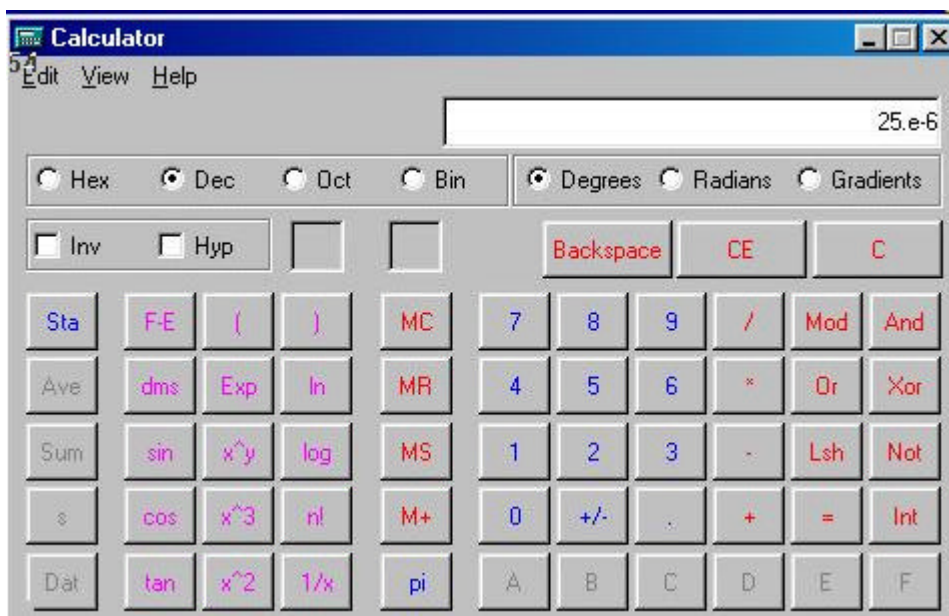
Press 5

Press EXP

Press 6

Press +/-

The display on the calculator will now read.



Press '/' - divide

Now enter 50 milliohms

Press 5

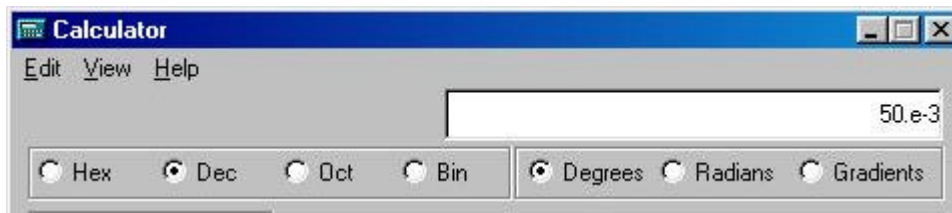
Press 0

Press EXP

Press 3

Press +/-

The display now shows



And final to get your answer of $25 \times 10^{-6} / 50 \times 10^{-3}$

Press =



So the answer as shown above is 0.0005 Amperes.

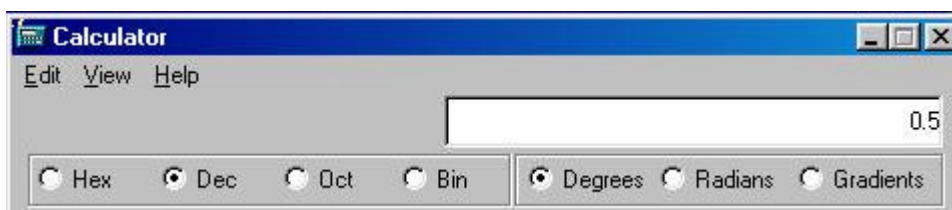
It would be more appropriate to express this answer in milliamperes. Since a milliampere is $1/1000^{\text{th}}$ of an ampere to convert amperes to milliamperes you would multiply this result by 1000 - you could either do this in your head by moving the decimal point 3 places to the right or do it on the calculator. Your answer now will be in milliamperes and not amperes

To do it on the calculator you would :-

Press * (asterisk) [x] on other calculators

Press 1000

Press =



The answer is 0.5 mA (milliamperes)

Reciprocals

The reciprocal of a number is that number divided into one. All you need do on the calculator is enter the number you want the reciprocal of and press the reciprocal key.

This key simply has $1/x$ on it.



If there are any left over numbers in the display of the calculator say from a previous calculation you must clear the display with the clear key



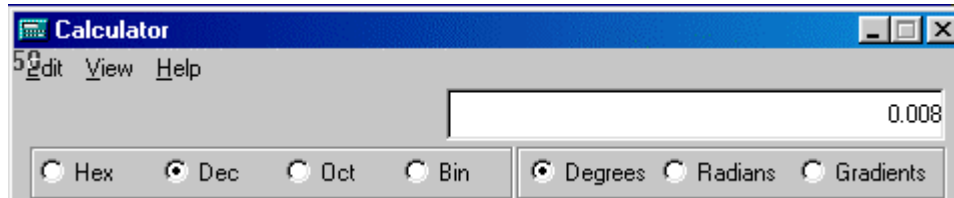
To find the reciprocal of 125 do this

Press the clear key

Press 125

Press $1/x$ (the reciprocal key)

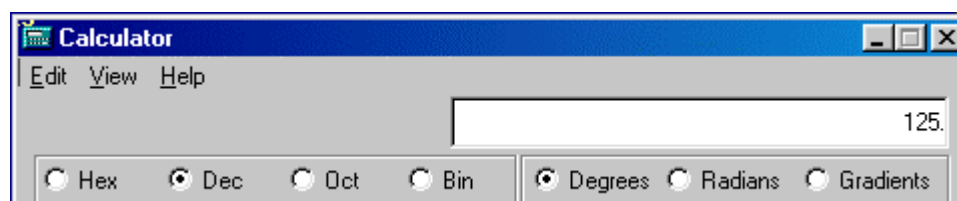
The display will now show: -



Therefore, the reciprocal of 125 is 0.008

The reciprocal of 0.008 is 125 - Not convinced!

Press $1/x$ again




And you are back to 125 in the display

The windows and other calculators operate in different number bases. For exam purpose you will always be using BASE 10, which is better known as 'decimal' so make sure your calculator is in decimal mode as the above diagrams show - this is the default mode and will not change unless you have changed it.

Square Root

If Z is the square root of Y then Z multiplied by Z equals Y
Put another way, the square root of say 9, is a number which when multiplied by itself equals 9. Now this is not a very hard one to work out. It is pretty obvious that the square root of 9 is 3 because $3 \times 3 = 9$. However for other numbers it's a lot harder to find the square root. It can be done by hand but it is slow and there is no need when you have a calculator.

Now the windows calculator does not have a square root key
On calculators that do have a square root function the key will look like this  or something very similar.

When you see a number something written like this 2^3
It is read as 2 to the power 3 and means $2 \times 2 \times 2 = 8$. Another example what is 8^2 Means 8 to the power 2, or $8 \times 8 = 64$.
When it is a simple number it is easy to work out problems like this in your head.

Now it happens that anything raised to the power 0.5 will give you the square root of that number.

The expression $9^{0.5}$ means the square root of 9 which is 3.
Now this is a bit tough to work out in your head. However, the windows calculator has a key which allows you to evaluate any number raised to any power (within the limits of the calculator)

This is the key



Lets try to work out the square root of a number we know - 9

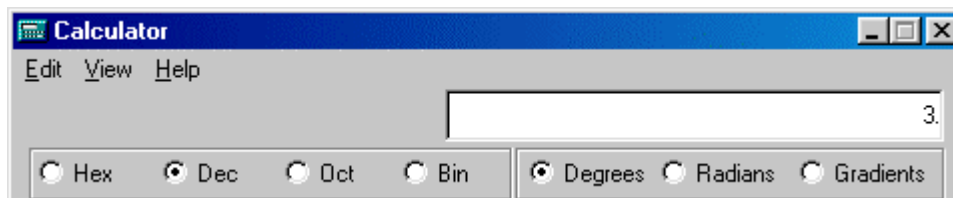
Press the clear key

Press 9

Press X^Y

Press 0.5

Press =



The answer as shown above is 3 which indeed is the square root of 9 as $3 \times 3 = 9$.

Find the square root of 2

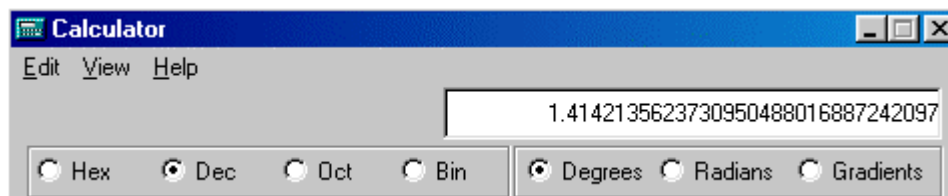
Press the clear key

Press 2

Press X^Y

Press 0.5

Press =



The square root of 2 rounded is 1.414

This is a number you will use in your study. For example to convert RMS voltage to peak voltage you multiply by 1.414 - a more accurate formula is $\text{RMS} \times \text{square root of } 2$

PI

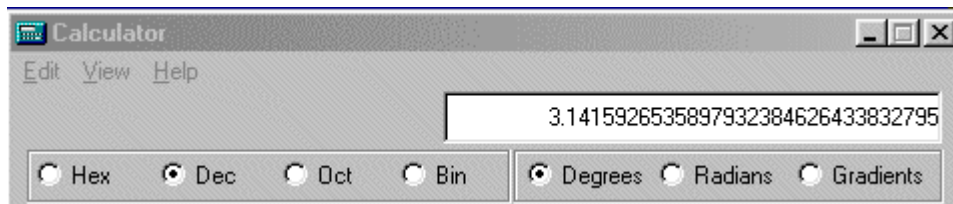
Another useful constant you will use a lot is PI. If you take the radius of any circle it will divide into that circles

circumference π times r . Often π is shown with the Greek letter which is called π and has the symbol π

Your calculator will either have π on the key or the symbol π . If you need to use π in a calculation all you need do instead of entering in π is press the π key.



Press the clear key
Press π



As you can see from the above the calculator gives you π with a high degree of accuracy. Often π is simplified to $22/7$.

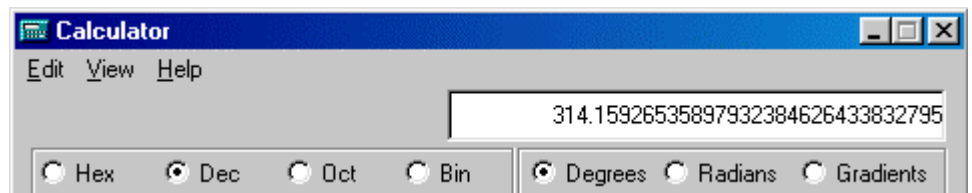
The circumference of a circle (C) is give by $2\pi r$
 r = the radius

This formula means $C = 2 \times \pi \times r$

When there are no multiply signs between the symbols you take it that they are there.

What is the circumference of a circle which has a radius of 50 metres?

Press the clear key
Press 2
Press * (multiply)
Press π
Press *
Press 50
Press =



Or 314.16 metres.

Lets try to do an example which many have trouble with in the course and that is the equation

$$R = \mathbf{r}/A$$

R = Resistance of a wire

r = is the resistivity of the wire

l = the length of the wire

A = the cross sectional area of the wire

Assuming the wire is round 'A' can be found from $\mathbf{P}d^2$

If you can do this on the calculator you will not have any trouble with anything (much) 😊

$$\mathbf{r} = 2.44 \times 10^{-8}$$

$$\mathbf{l} = 55 \text{ metres}$$

$$\mathbf{d} = \text{the diameter of the wire} = 0.6 \text{ millimetres}$$

$$R = \mathbf{r}/A$$

We can't use this equation yet because we don't know 'A' however we do know the diameter and from that we can calculate 'A' for $A = \mathbf{P}d^2$

$$A = \mathbf{P} \times (0.6 \times 10^{-3})^2$$

Press the clear key

Press PI

Press *

Press 0.6

Press EXP

Press 3

Press +/-

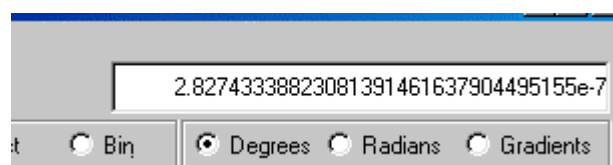
Press X^2



Press /

Press 4

Press =



So the cross sectional area 'A' is
2.82743338823081391461637904495155e-7 square metres

Now this is a pretty large and cumbersome number to write down. You could write it down and enter it in again later however a better way is to place this number into the calculator's memory. The memory keys on the Windows calculator are:-



MC - means clear the memory



MR - transfer the memory to the display



MS - Means store the number in the display in memory



M+ means add the number in the display to the one in memory

Press MC (this makes sure the memory is cleared)

Press MS (this stores our number for the area in memory)

$$R = r/A$$

When can now continue to calculate R using the above equation and know the 'A' is stored in memory for recall when we want it.

Press the clear key

Press 2.44

Press EXP

Press 8

Press +/-

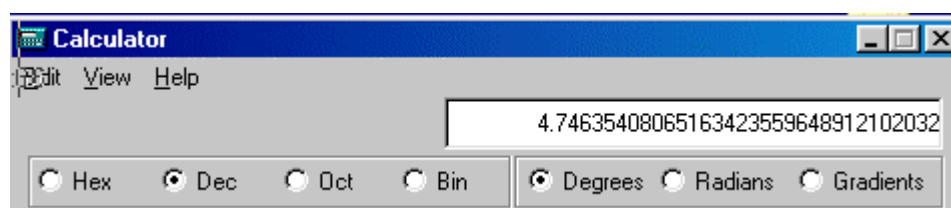
Press *

Press 55

Press /

Press MR (which reads 'A' from memory into the display)

Press =



The resistance of an aluminium wire 55 metres long with a diameter of 0.6 mm is 4.75 Ω (neglecting temperature).

Logarithms

Logarithms are explained in the readings so I will not do so here again. I will say there are different types of logarithms though the two main types are :-

Natural logarithms



And

Common Logarithms



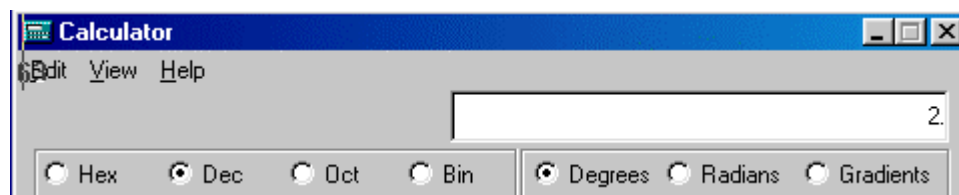
The type you will need to use for exam purposes is the common logarithm. If you are not sure which key is the correct common log key on your calculator just find the log of 100 - which is normally written $\log(100)$ - if you are using common logs the answer will be two.

Let's do it on the windows calculator

Press clear all

Press 100

Press log



The common log of 100 is 2 because $10^2=100$

$$dB = 10\text{Log}(P1/P2)$$

Calculate the number of decibels (dB) if P1 is 100 watts and P2 = 50 watts

$$DB = 10\text{Log}(100/50)$$

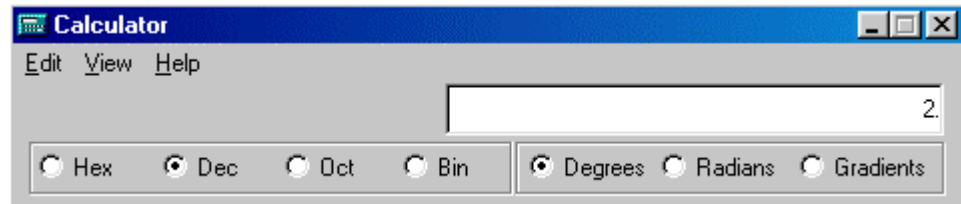
Press the clear key

Press 100

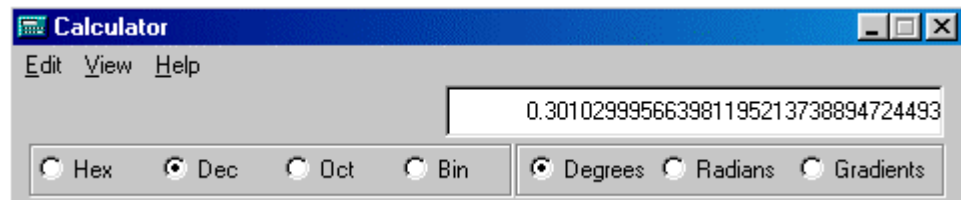
Press /

Press 50

Press =



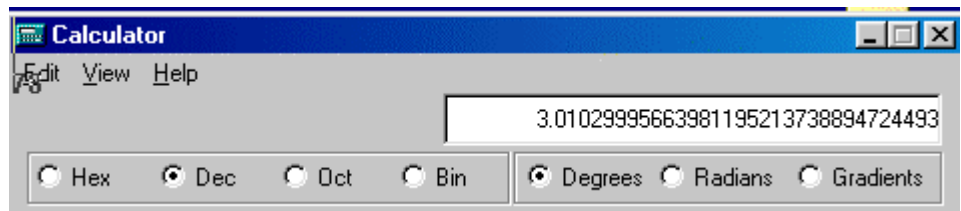
Press Log



Press *

Press 10

Press =



Or close enough to 3 decibels.

Resonant Frequency

One of the equations you will have to use during the course is that of resonant frequency.

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

f_r = resonant frequency

L = 50 μ H (micro henries)

C = 200 pF (picofarad)

$$f_r = \frac{1}{2\pi\sqrt{(50 \times 10^{-6} \times 200 \times 10^{-12})}}$$

With this equation you must first multiply L and C then find their square root, then multiply by 2π and lastly find the reciprocal of the answer.

Press the clear all key

Press 50

Press EXP

Press 6

Press +/-

Press *

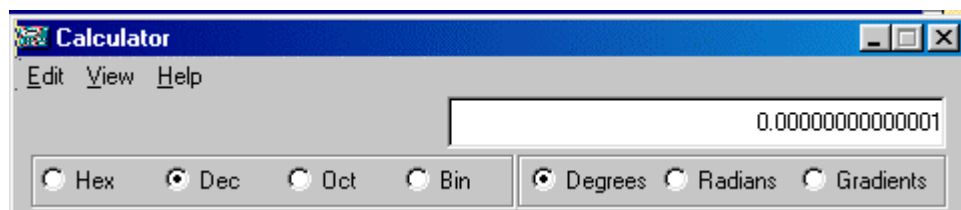
Press 200

Press EXP

Press 12

Press +/-

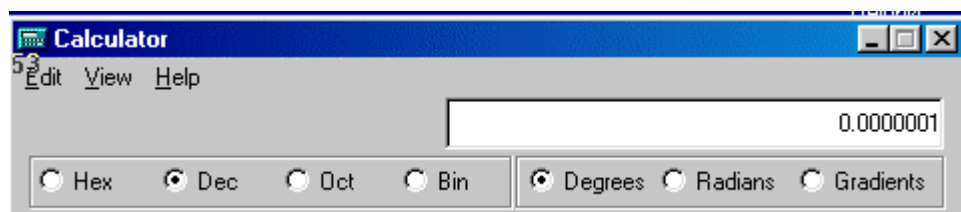
Press =



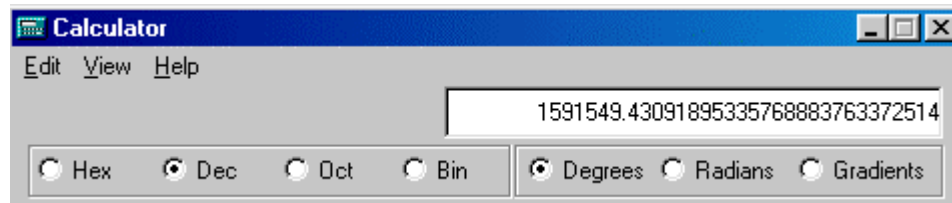
Press X^Y

Press 0.5

Press =



Press *
Press 2
Press *
Press PI
Press =
Press 1/X



1591549.43091895335768883763372514 Hertz

which better expressed as megahertz by dividing by 1,000,000

1.59 MHz (rounded)

This file is to be completed

I have not checked for errors - if you think there are any please do let me know. I would also like some feedback if you find this type of tutorial using the calculator of benefit.

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