

## QAMA User Instructions®

Once upon a time products were sold without a book, We are trying to bring these times back: The following sheet consists of only essential, QAMA-specific instructions. **Please read them** - with the calculator at hand.

*Before first use, pull out the tab projecting from the battery compartment at the back, and peel the film off the display*

To start press **on**      The display contrast can be raised stepwise by pressing **2<sup>nd</sup> 5**, lowered by **2<sup>nd</sup> 2**

- Note: Lower-case keys are referred to here in **bold** e.g. **x** or **sin**; Upper-case keys (preceded by pressing **2<sup>nd</sup>**) are underlined e.g. off or log. (On the display, the key **x<sup>y</sup>** is shown as **^**, **x<sup>1/y</sup>** as **1/y**, **(-)** as shorter, lowered - )
  - *Always verify entries by watching the display; Verify the markers in the (top) status line e.g. under the 2nd upon pressing **2<sup>nd</sup>***
  - **In estimating the expected result refer also to the source of the calculation**
  - *After entering a Calculation, press **=**; Normally, the cursor jumps then to the bottom left 'Estimate' position awaiting a reasonable **mental** estimate – **again followed by =**; If and only if QAMA considers the estimate reasonable for the respective Calculation will it display the **Precise\* Answer**. Otherwise, the Estimate position is cleared, awaiting a better one. An Estimate must be a number only (can use **E**), not an expression .*
  - Required accuracy for Estimate acceptance: The best reasonably possible, fully understanding the constituents
  - After completing a task – with the Calculation, the Estimate and Precise Answer showing, the next key-stroke will clear the screen and start the next Calculation.
  - rpt will re-present (i.e. 'repeat') the previous Calculation - the one entered before the most recent **=** .
  - Do not omit operators e.g.  $3\sqrt{5}$  should be **3x√5** ,  $4\cos 59$  should be **4xcos59**
  - If, after pressing **=**, the cursor does not jump to the Estimate position but goes back to the start of the Calculation it means something is wrong in the input:
    - a) a syntax error occurred e.g. **4xx5**, **5cos20**, **4.2.8** etc.
    - b) an incomputable operation e.g.  $\sqrt{(7-9)}$ , **acos1.1** , values outside the range of  $\pm(10^{-99}$  to  $10^{99})$
    - c) the input exceeded the limit of 40 Calculation items (numbers & operators):  
e.g. **1234x5.67** is 3 items. **cos** is 1 item, so are **'( ' ' ) ' (-)**
- If at some stage the display ceases to accept further keystrokes, the input is exceeding the allowed 75 key-strokes. ( **1234x5.67** is 9 key-strokes, **cos** is 1 key-stroke. )
- In the Estimate position, if after entering the estimate and **=** no Precise Answer appears but the Estimate does not vanish either and the cursor goes back to the left, a syntax error occurred in the Estimate (which must then be corrected by editing – see below).
  - To erase the entire entry (but not the memories, the previous Calculation and its Answer) and re-start, press off, **on**

- Editing: Both the Calculation and the Estimate can be edited by using ← and → to move the cursor, and there delete by using **del**, or insert (by default). The Calculation can be edited only before the = is pressed. To edit the Calculation after the = was pressed press off , **on**, rpt and proceed editing (or re-enter a Calculation)
- Long numbers can be entered using **E** e.g. 123450000000 as **1.2345 E11** , 0.0000012345 as **1.2345 E (-)6**
- Do not confuse between the ‘minus’ – and the ‘negative (-), e.g. **8 – 3 and 8 x (-)3**
- D/R switches between Deg and Rad (only before the ‘=’); A marker at the top of the display indicates the current unit

\* correct to 9 significant figures

- Order of entries: As they are pronounced e.g. **sin40**  $\sqrt{7}$  **7<sup>2</sup>**
- Execution order of operators/functions: (The (-) belongs to its immediate follower – number, pre-function or bracket)  
Proceeding from left to right: encountered brackets get top priority -innermost first. Otherwise:

(**exe**: Execute current op./fn →: Consider following op./fn if any)

Following op/fn: with or without an intermediate number	+, -	×, ÷	x <sup>y</sup> , x <sup>1/y</sup>	x <sup>2</sup> , 1/y, n <sup>!</sup>	trig, √, log, ln, e <sup>x</sup> , 10 <sup>x</sup>	(none)
Current op/fn						
+, -	<b>exe</b>	→	→	→	→	( <b>exe</b> )
×, ÷	<b>exe</b>	<b>exe</b>	→	→	→	( <b>exe</b> )
x <sup>y</sup> , x <sup>1/y</sup> (bin. fn)	<b>exe</b>	<b>exe</b>	<b>exe</b>	→	→	( <b>exe</b> )
x <sup>2</sup> , 1/y, n <sup>!</sup> ... (post fn)	<b>exe</b>	<b>exe</b>	<b>exe</b>	<b>exe</b>	→	( <b>exe</b> )
trig, √, log, ln, e <sup>x</sup> , 10 <sup>x</sup> (pre fn)	<b>exe</b>	<b>exe</b>	→	→	→	( <b>exe</b> )

For example: **4 + 2 × 3 ^ cos 8<sup>2</sup>** gets executed in the reverse order i.e. **8<sup>2</sup>** first, **cos** next etc. because the **+** followed by **×** shows →, so it is not executed yet; same with **×** followed by **^** etc.; (8)<sup>2</sup> - followed by no op/fn- it shows **exe**, so it is executed. After (8)<sup>2</sup> was executed, **cos** (trig) is now *not* followed by any op/fn, so now it *is* executed. Next- same for the **^**, **×**, **+**

- If in doubt about the order of execution– try it out in the EACH mode: It will present the sub-Calculations in the order in which they are executed.

- There *are* fractional powers of negative numbers which *have* a (real) root. Watch out whether it is +ve or -ve
- Of multiple roots, only the real positive one is used.
- If 5 attempts were unsuccessful, eventually the Precise Answer is shown anyway, but only if further attempts are being made. To avoid the long wait, keep thinking– a good estimate will produce the Precise Answer immediately
- There are three Modes: (The present mode is indicated by a marker at the top right of the display)  
EST the regular (and default) mode,

EACH allows estimating each step of a (composite) Calculation separately: The entire Calculation appears briefly, then only the sub-Calculation to be estimated (or re-estimated). If the sub-estimate is accepted, its correct value overwrites the respective part of the Calculation, again showing the whole Calculation (with its already estimated parts now overwritten by their correct values) for a short time, and then again displaying only the part that needs to be estimated next. Only the final answer is shown in the 'Precise Answer' field in the bottom line, while the top line shows the last state of the Calculation. At any stage *before the final answer is shown*, the whole Calculation reappears briefly upon pressing =.

EST converts the QAMA calculator into a lazy ordinary calculator. However, in this mode, warning lights are flashing. (Switching back to EST or EACH or switching off will not help - the flashing continues (for a while) )

Modes can only be changed before '='

→ **Note:** In the EST mode, and also while waiting for 'showing the answer anyway', more current is consumed

As calculators compute in binary form but display decimal results, on rare occasion a 0 result could appear as a tiny fraction e.g. 3E-16

- When  $\pi$  is entered it is displayed as **3.14159265**, except in cases of familiar fractions of  $\pi$  as radian arguments in trigonometric functions e.g. **cos( $\pi/2$ ) sin( $\pi/6$ ) tan( $\pi/4$ )** (where  $\pi/2$  is recognized as  $90^0$ ,  $\pi/6$  as  $30^0$  etc.)
- When the allowed input exceeds the two available lines, the beginning of the Calculation is 'pushed out' to the left – indicated by a '-' marker at the top left. Upon pressing = the beginning of the Calculation reappears, and its end is now pushed out to the right - indicated by '>' at the bottom right. The Calculation is now 'ordered' i.e. with no numbers split between the two lines or partially pushed out at either end. So that the entire Calculation can be evaluated, each further = scrolls the Calculation leftwards, i.e. pulls in another Calculation-element at the bottom right and pushes some out at the top left. The markers always indicate if anything is 'hiding' behind the left &/or right 'walls'. Further = after the end of the task was shown, restarts the cycle. At any time can the estimate be entered.

**Note:** After pressing = and after the brief appearance of the entire current Calculation, if then nothing remains on the screen, this means that the next sub-Calculation which requires an interim estimate is 'hiding behind the wall' and repeated = will bring it in.

- xxx**sto** followed by 'n': Stores xxx (which can be a numbers or bracketed expression) in memory n (1 to 9). A mark at the top of the display indicates that memory n is then occupied. If xxx is a (bracketed) expression it is presented for estimation and gets stored only if the estimate is accepted.

Following the xxx**sto** with +n or -n i.e. xxx**sto+n** or xxx**sto-n** adds xxx to (or subtracts from) the value already stored in memory n. Upon =, firstly this addition (or subtraction) is presented for estimation: The summing into memory n is performed only if the estimate is accepted.

- **rc|n** brings out the value stored in memory n. (If nothing had been stored in n the cursor jumps to the start)  
Example: (using memory 2) **5.1sto2 ÷ (3.1^2)sto+2 × rc|2**: Upon = a mark appears under memory 2 (since the 5.1 got stored there), and an estimate is requested for the bracketed expression **3.1^2** ; If accepted, then **5.1+9.61** is asked about (9.61 -showing the precise value of 3.1^2); If this sum is accepted it replaces memory 2 with the precise answer of this sum (14.71) which is then recalled for the final estimation of **5.1÷9.61×14.71**
- **cm** clears all the memories, it can only be used before a new Calculation is entered.
- **ans** recalls the Precise Answer of the previous completed task
- Even in the **EST** mode occasionally a sub-Calculation needs to be estimated separately. (This happens for a good reason which is not explained for an even better reason.)
- **off** extinguishes the display (to save power). This will happen automatically a couple of minutes after the last keystroke. The memories, the last inputted completed Calculation and its Precise Answer will be kept for ~20 minutes, during which any keystroke will switch the display back on. ~20 minutes after the last keystroke (in ~~EST~~ mode after 7 min.) the calculator switches off completely, clearing all history. To restart, press **on**.

**Please note: The objective is not a uniform level of accuracy, but a uniform depth of understanding. This, in some cases, can only be proven by a fairly accurate estimate, while in other cases a rougher estimate could provide the evidence. This is separate from the variance of tolerances as dependent on the complexity of the calculation.**

Batteries: 2×AAA - make sure to insert both in the same correct direction: flat ends towards the spring

In case of suspected malfunction firstly re-inset the batteries and if necessary replace them. Beware: Dead batteries can cause damage.

Keep batteries away from children. Recharge only rechargeable batteries.

Do not expose the calculator to strong direct sunlight or to extreme heat, cold, humidity, dust.

Do not drop, bend or wet the calculator.

When not in use, always keep the calculator in its box

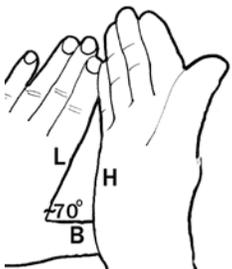


**Some Estimation Leads**<sup>©</sup> -for students and/or the teachers [ $\approx$ : approximately=,  $\sim$ : approx.  $>$ : more than,  $<$ : less than]

*No calculation should ever be attempted until the meaning of the operators and functions is understood!*

Then, aim for the best possible *mental* estimate using little, reasonable, effort.

- Remember there is no tolerance for:
  - decimal orders of magnitude (except for some very large results)
  - sign (+ or -) (except for some very small unobvious results)
  - basic operations with single digits
- Multiplication/Division - Use rounding: (i.e.  $37.8 \rightarrow 40$   $11.3 \rightarrow 10$ )  
 $37.8 \times 11.3 \approx 40 \times 10$  ( $\because$  both rounded in **opposing** directions)  $43.1 \div 11.3 \approx 40 \div 10$  ( $\because$  both rounded in **same** direction)  
 $42.1 \times 11.3 > 40 \times 10$ , say  $\sim 440$  ( $\because$  **both** rounded down)  $58.4 \div 11.3 < 60 \div 10$ , say  $\sim 5.5$  ( $\because$  top rounded up, divider down)
- Addition/subtraction Apply estimation mainly to the decimal positions that are mutually occupied (i.e. non-zero):  
 $1234567 + 231$ : The '1234' are not affected by the +231 (the '4' is only in case of overflow e.g.  $1234567 + 631$ );  
 $1030507 + 204060$  is (exactly, and easily so)  $1234567$
- Trigonometry
  - Expected knowledge: meaning of sin, cos, tan, and their values\* (in all quadrants) at  $0^\circ$  &  $90^\circ$ ,  $\sin 30^\circ$ ,  $\tan 45^\circ$ ,  $\cos 60^\circ$ . Also, whether the functions grow or decrease with growing angles
  - For small angles sin & tan are similar to the angle in radians. As  $1^\circ$  is  $\sim 1/60$  of 1rad so  $\sin 1^\circ$  &  $\tan 1^\circ$  are  $\approx 1/60$   
 Another way:  $\sin 30^\circ = 0.5$ , so  $\sin 1^\circ \approx 0.5/30$  ( $\approx 0.016$ , - also  $\tan 1^\circ$ )
  - $\tan 89^\circ = 1/\tan 1^\circ \approx 1/(1/60) = 60$
  - $\tan 5.5\text{rad}$ : A full circle (in rad) is  $2\pi \approx 6.28$ , so  $5.5\text{rad}$  is  $\sim 0.75\text{rad}$  short of the full circle; As 1rad is  $\sim 60^\circ$   $0.75\text{rad}$  would be  $\sim 45^\circ$ , so the  $5.5\text{rad}$  is approx.  $45^\circ$  in the 4<sup>th</sup> quadrant, thus  $\tan 5.5\text{rad} \approx -1$
  - To estimate any trig. function with bare hands: Use the thumb and finger to make up the approximate angle, provide the 'opposite' by placing the edge of your other hand perpendicular to the thumb, look at the resultant right-angle triangle and estimate the ratio between the respective sides:



Trig functions of, say,  $70^\circ$ :

Between thumb and finger, form an angle clearly greater than  $45^\circ$  and less than  $90^\circ$ :

$\tan \alpha$  is  $H/B$ ;  $H$  looks somewhat greater than twice  $B$ , so  $\tan 70$  can be estimated as 2.3 say, 2.5 ...

$\sin \alpha$  is  $H/L$ ;  $H$  looks somewhat less than  $L$ , so  $\sin 70$  can be estimated as 0.8 say, 0.9 ...

$\cos \alpha$  is  $B/L$ ;  $B$  looks like  $\sim 1/3$  of  $L$ , so  $\cos 70$  can be estimated as 0.3 say, 0.35 ...

- Sq.roots: Expected knowledge\*: The squares of 1 -10, so  $\sqrt{76.5}$  must lie between 8 & 9; This way the root of any number between 1 & 100 can be estimated. For numbers between 100 & 1000 all one needs is extrapolate between  $\sqrt{100}$ ,  $\sqrt{400}$  and  $\sqrt{900}$ . For 1000 - 10,000:  $\sqrt{7652}$  is ten times  $\sqrt{76.52}$  i.e  $\sim 85$ . Then,  $\sqrt{xx,xxx}$  is  $10 \times \sqrt{xxx}$  etc.  
 Other roots (cubic etc.): By trial and error (*and* success) , or by using Logs - but *only* if understood!

- Powers:** Expected knowledge\*:  $A^{(n+m)} = A^n \times A^m$ ,  $(A^n)^m = A^{n \times m}$ ,  $A^{0.5} = \sqrt{A}$ , Powers of 2 e.g.  $2^{10} \approx 1000$

- Small powers: estimated by approx. repeated multiplication:  $7.3^{4.5} = 7.3^{(2+2+0.5)} = 7.3^2 \times 7.3^2 \times \sqrt{7.3} \approx 50 \times 50 \times 2.5 \approx 6000$   
 $77^{2.3} = 77^2 \times 77^{0.3}$ :  $77^2 \approx 6000$ ;  $77^{0.3}$ : between  $\approx 77^0$  and  $77^{0.5}$  i.e. between 1 &  $\sim 9$ , say 4; So,  $77^{2.3} \approx 6000 \times 4 = 24000$

- Large powers: Logs can be used, but only if understood. More 'transparently': Break up the exponent n to  $p \times q$ , so  $A^n = A^{p \times q} = (A^p)^q$ , and choose 'p' so that  $A^p$  is  $\sim 2$  or  $\sim 10$  (or 100). Then,  $2^q$  or  $10^q$  are easy to evaluate.  
 Example:  $1.08^{120}$  (this is what happens to the cost of a \$1 sandwich after a year of prices rising every 3 days by just 8%):  
 $1.08^2 \approx 1.16$ ;  $1.16^2 (\approx 1.08^4) \approx 1.33$ ;  $1.33^2 (\approx 1.08^8) \approx 1.8$ ; then  $\times$  another 1.08 (i.e.  $1.08^9$ ) brings this to  $\approx 2$ ;  
 So, p is 9 and  $q = 120 \div 9 \approx 13$ ; Therefore  $1.08^{120} \approx 2^{13} \approx 2^{10} \times 2^3 \approx 1000 \times 8$  (The actual result is 10253 (!))
- $e^x$  Expected knowledge\*: If x is small (less than  $\sim 0.5$ )  $e^x \approx 1+x$  (and therefore  $\ln y \approx y-1$  for  $y=1+\text{small } x$ )
- log, ln** Expected knowledge\*:  $\ln W = \log W \times \ln 10$  ( $\ln 10 \approx 2.3$ ) or:  $\log A \approx \ln A \div 2.3$   
**Express W as  $A \times 10^N$  where  $1 < A < 10$**  (e.g. in 132  $A=1.32$  and  $N=2$ ) so  $\log W = \log A + \log 10^N = \log A + N$   
 - For  $A=1$  to  $1.5$ : As  $\log W = \log A + N$ ,  $\log A \approx \ln A \div 2.3$ ,  $\ln A \approx A-1$ , so  **$\log W \approx (A-1) \div 2.3 + N$**   
 i.e.  $\log 132 = (1.32-1) \div 2.3 + 2 \approx 2.14$   
 - For  $A=1.5$  to  $10$ :  **$\log W \approx A/10 + 0.1 + N$** , i.e. for 0.068 ( $A=6.8$   $N=-2$ ):  $\log 0.068 \approx 6.8/10 + 0.1 - 2 \approx -1.2$   
 -  **$\ln W$** : For  $W > 0.5$  and  $< 1.5$   **$\ln W \approx W-1$** ; For  $W > 1.5$  or  $< 0.5$   **$\ln W \approx \log W \times 2.3$**  i.e.  $\ln 0.068 \approx -1.2 \times 2.3 \approx -2.7$
- n!** (n integer between 1 & 69) An effective approximation for large n is  $(0.4n)^n$  e.g.  $20! \approx (0.4 \times 20)^{20} \approx 8^{20}$   
 (which is  $(2^3)^{20} \approx 2^{60} \approx (2^{10})^6 \approx 1000^6 \approx 1E18$ )

\* with the reasons, of course