HP35s / HP12c Programs

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Revision History

Revision Date	**Description**
May 25, 2016	Revised *Modular Exponentiation* program by using DSE function instead of direct variable count.
June 26, 2021	Renamed *Modular Exponentiation* to *modexp.* Added blank pages for double sided printing. Added program to calculate actual VSWR based on measured VSWR and cable loss.

Contents

Part I

HP35s

0.1 modexp

Description

This program calculates the modulus of a number raised to a large power. The formula looks like this:

$$modexp = n^p \mod m$$

Usage

`GTO A001` n `R/S` p `R/S` m `R/S`

Program Listing

`A001`	`LBL A`	start of program
`A002`	`STO N`	store number to the raised to the power P
`A003`	`STOP`	wait for user R/S
`A004`	`STO P`	store exponent
`A005`	`STOP`	wait for user R/S
`A006`	`STO M`	store modulus
`A007`	`1`	initialize product ...
`A008`	`STO R`	... and save in memory
`A009`	`RCL N`	recall base ...
`A010`	`RCL R`	recall product ...
`A011`	×	... and multiply the two
`A012`	`RCL M`	recall the modulus ...
`A013`	`RMDR`	... and apply it
`A014`	`STO R`	save the new product
`A015`	`DSE P`	decrement exponent ...
`A016`	`GTO A009`	... and loop back if not finished.
`A017`	`RCL R`	pull the product from memory
`A018`	`RTN`	we are done!

Example

In the following example we calculate $\mathbf{5^{101}}$ mod **31** using the following steps:

`GTO A001`	`0.00000`	go to start of program
`5 R/S`	`5.00000`	the "base"
`101 R/S`	`101.00000`	the "exponent"
`31 R/S`	`25.00000`	the "modulus" and result

Comments

The HP35s is not known for it's lightning speed. The above example will take about 12 seconds to run.

0.2 atan2

Description

This program calculates atan2($\frac{y}{x}$). Result is in the range $-180°$ to $+180°$.

Usage

`GTO Z001` x `R/S` y `R/S`

Program Listing

`Z001`	`LBL Z`	Start of program.
`Z002`	`STO X`	Store x in `X`.
`Z003`	`STOP`	Wait for user R/S.
`Z004`	`STO Y`	Store y in `Y`.
`Z005`	`RCL Y`	Recall `Y`. Note: this is also the entry point for subroutine.
`Z006`	`RCL X`	Recall `X`.
`Z007`	$\div$	Take ratio of rise over run ($\frac{y}{x}$).
`Z008`	`ATAN`	Calculate arctan($\frac{y}{x}$).
`Z009`	`STO R`	Save as an interim result in `R`.
`Z010`	`RCL X`	Test sign of `X`.
`Z011`	$x > 0$?	Is x positive?
`Z012`	`GTO Z027`	If so then go to end of program.
`Z013`	`RCL Y`	Recall `Y` ...
`Z014`	`SGN`	Calculate its sign ...
`Z015`	`45`	
`Z016`	$\times$	then multiply it by 45°.
`Z017`	`RCL X`	Get `X` value.
`Z018`	$x = 0$?	Is it equal to zero?
`Z019`	`RTN`	If so then return the value of the stack ($\pm 45°$)
`Z020`	`180`	Setup offset depending on sign of y.
`Z021`	`STO -R`	Initially subtract 180°— we do this at a minimum.
`Z022`	`RCL Y`	Get `Y` value.
`Z023`	$x < 0$?	Is it negative?
`Z024`	`GTO Z027`	If yes, then we are done since we already subtracted 180°.
`Z025`	`360`	If y is positive then we have to add 360°...
`Z026`	`STO +R`	... for a total addition of 180°.
`Z027`	`RCL R`	Get the angle.
`Z028`	`RTN`	Return to calling function.

Example

In the following example we calculate $\text{atan2}(\frac{+1.5}{-1.0})$ using the following steps:

`GTO Z001`	`0.00000`	Go to start of program.
`1.5`	`1.5`	Your value for x.
`R/S`	`1.50000`	
`-1.0`	`-1.0`	Your value for y.
`R/S`	`-33.69007`	The resulting angle.

Comments

Users have to be careful about a couple of things:

1. Angles are calculated in *degrees*. Confirm calculator setting before using this function.
2. User is responsible for ensuring that x and y are **never** both zero.

0.3 avswr

Description

This program calculates actual VSWR given measured VSWR and cable loss to antenna.

Usage

`GTO V001` M `R/S` L `R/S`

Program Listing

V001	LBL V	Start of program.
V002	STO M	Save measured VSWR in M.
V003	STOP	Pause for entry of cable loss (in dB)
V004	+/−	Negate cable loss ...
V005	10	... and convert to ratio
V006	÷	
V007	10^x	
V008	STO L	Save as cable loss
V009	RCL M	Get measured VSWR and calculate reflected power ratio
V010	1	
V011	−	
V012	RCL M	
V013	1	
V014	+	
V015	÷	
V016	x^2	
V017	STO R	Save reflected power ratio
V018	RCL L	Calculate actual VSWR at antenna
V019	$\sqrt{x}$	
V020	RCL R	
V021	RCL L	
V022	÷	
V023	$\sqrt{x}$	
V024	+	
V025	RCL L	
V026	$\sqrt{x}$	
V027	RCL R	
V028	RCL L	
V029	÷	
V030	$\sqrt{x}$	
V031	−	
V032	÷	
V033	RTN	Return to calling function.

Example

Calculate the actual VSWR of an antenna where the measured VSWR is 1:1.13 and cable loss is 4.7dB:

`GTO V001`	`0.00000`	Go to start of program.
`1.13`		Your value for M (measured VSWR).
`R/S`	`1.13000`	
`4.7`		Your value for cable loss L.
`R/S`	`1.4394`	Actual VSWR at antenna is 1:1.4394

How this program works

$VSWR$ is the ratio of the sum and difference of forward and reflected voltages:

$$VSWR = \frac{V_f + V_r}{V_f - V_r} \tag{1}$$

Since power is proportional to the square of the voltage, (1) can be expressed in terms of power

$$VSWR = \frac{\sqrt{P_f} + \sqrt{P_r}}{\sqrt{P_f} - \sqrt{P_r}} \tag{2}$$

By setting P_f equal to 1 and rearranging (2) we can solve for P_r

$$P_r = \left(\frac{VSWR - 1}{VSWR + 1}\right)^2 \tag{3}$$

Cable loss is normally expressed in decibels but for our purposes we can simply express it as a factor of less than 1 where P_a is power at the antenna and P_t is power from the transmitter.

$$L = \frac{P_a}{P_t} \tag{4}$$

Taking into account the cable loss and measured forward and reverse power we can calculate VSWR at the antenna

$$VSWR = \frac{\sqrt{P_f \times L} + \sqrt{P_r \div L}}{\sqrt{P_f \times L} - \sqrt{P_r \div L}} \tag{5}$$

Again we set P_f to 1 so a simplied version of (5) becomes the actual VSWR at the antenna

$$VSWR = \frac{\sqrt{L} + \sqrt{P_r \div L}}{\sqrt{L} - \sqrt{P_r \div L}} \tag{6}$$