The INTSOL Module and the FROOT Equation Library.

A fairly obscure module - the "Interchangeable Solutions" ROM includes the UPLE program #01475C of the same title written by H. Suarez. The main addition is now a poor-man's SOLVER ("**SLV+**") and a modest Equation Library - with 28 equations in total.

SLV+ can deal with up to 5 variables (obviously three at least), and uses the {A-E} soft-keys for variable data entry and execution. It's a FOCAL program based on an old routine written by D. Brunell and possibly published on PPC (I lost the actual reference, let me know if you have it). It relies on the SOLVE function to find the roots of the equation, which is programmed in a way expected by the SLV+ routine. This means each equation in the library:

- Shows its own variables menu in the LCD when called by SLV+
- Stores the known variables (in regs. R01-R05) after data input (user flag 22 clear)
- Stores the unknown variable number (1 to 5) in R00, depending on the soft-key pressed without actual data input (user flag 22 is set)
- Includes the code for the SOLVE function to calculate the root within standard interval [0,1] or custom guesses.

The ROM includes 28 equations, but of course it's likely you'll write your own - using these as examples. The equations are listed below in alphabetical order:

1	"<)RLC	Delay Angle RLC
2	"BERN-A	Bernoulli w/Areas
3	"BERN-V	Bernoulli w/Velocities
4	"CATNRY	Catenary Equation
5	"F=Ma	Force Equation
6	"F=MMR2	Gravitation
7	"HEATX	Heat Exchangers
8	"HERON	Heron Formula
9	"ISENT	Isentropic Flow
10	"KEPLR	Kepler Equation
11	"MPAD	Michell Pad
12	"MVT	Linear Movement
13	"ORBIT	Orbital Trajectory
14	"PRJT-D	ProjectileDisplacmnt.
15	"PRJT-V	Projectile Velocity
16	"PV=ZNT	Ideal Gas EOS
17	"ΣPR	Parallel Resistors
18	"REDLCH	Redlich-Kwong EOS
19	"RFLC	Resonance Frequency RLC
20	"RPM=TP	Torque Equation
21	"SRL-AC	Serial RL AC Control
22	"TVM	Time Value of Money
23	"V=IR	Ohm's Law
24	"VMOD	Vector Module
25	"VWAALS	Van-der Waals EOS
26	"Y=aX+b	Linear Equation
27	"Y=PX2	Quadratic Equation
28	"Y=PX3	Cubic Equation

The equation routines are not meant to be called directly by the user. If you do so, make sure that:

- all the input data are already in the appropriate registers,
- the number of the unknown variable (1 to 5) is stored in R00,
- its (guess) value is in the X register upon entry, and
- F 06 is clear to execute the routine, or Set to show the menu.

Also notice that data registers R00 to R06 are reserved, and that user flags F4, F5, and F6 are used to signal the data input or execution modes, and F0 is reserved for optional changes within a given equation.

The programs support up to five variables in the equations. In a couple of cases a sixth variable is added in a direct prompt – not part of the menu and therefore only as a known input. This is not ideal but a realistic compromise to work around the limitation. The following pages provide more details on these equations and their usage within the INTSOL module.

General comments:

You can press [R/S] at the "a^b=?" prompt to use the defaults. The default guess is the interval [0,1]. Most of the equations will find a root with this default setting, but using more accurate ones will likely reduce the execution times. Note however than *custom guesses are always needed for those variables in a denominator of the formulas*.

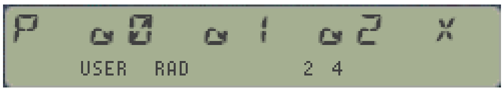
The "**SLV+**" program assumes the existence of at least three variables. Pressing the [**D**] and [**E**] keys for equations without a fourth or fifth variable will save the value in the data register (R04 / R05) but will *not* trigger the execution of **FROOT** (the menu will be shown again).

If no solution is found by **FROOT** the program will show the variables menu again. You can then modify the inputs or repeat the calculation with different guesses. On the other hand, if a DATA ERROR condition is encountered while calculating the equation the execution will stop in that routine, and you'll need to re-start the **SLV+** program.

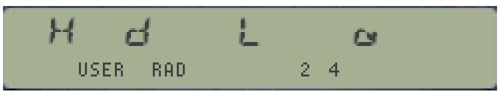
Remember also that the accuracy of the solutions is directly affected by the number of decimal places set in the display settings.

1. Math & Finance equations.

Heron Formula for Triangle area.		
Equation:	A = ¼ sqrt [(2a.b)^2 – (a^2 + b^2 – c^2)^2]	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “HERON”		2ab > (a^2 + b^2 + c^2)
Example. Given a = 2, b = 3 , c = 4 Solves: A = 2.904737510		

Linear, Quadratic & Cubic Equations.		
Equations:	y = a2.x^2 + a1.x + a0 y = x^3 + a2.x^2 + a1.x + a0	y = a.x + b
Options:	CF 00: n/a	SF 00: n/a
Variables Menus: LBL “Y=aX+b” LBL “Y=PX2” LBL “Y=PX3”	 	
Example. Given a0 = 1, a1 = -4, a2 = -1, P =0, and default [a,b] = (0, 1) Solves: x = 0.236067978 for quadratic, and x= 0.239123279 for cubic.		

3-D Vector Module.		
Equation:	|V| = sqrt(X^2 + Y^2 + Z^2)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “VMOD”		*Use z=0 for 2-D cases*
Example. Given |v| = 5, x = 2, y = 4 Solves: y = 2.236068		

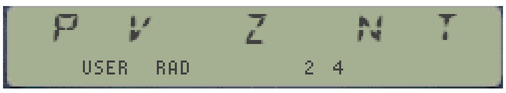
Catenary Equation.		
Equation:	d =H [1 - (1/cosh(V/2a))]	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “CATNRY”		*Curve is symmetric.* *“a” needs custom guess*
Example. Given H = 42 m, L = 100 m, a = 43.5 m Solves: d = 17.814791 m		

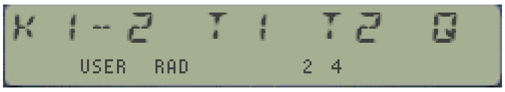
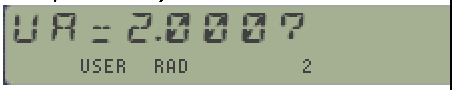
Time Value of Money.		
Equation:	0 = PV + (1 + ip) PMT/i [1- (1+i)^(-n)] + FV (1+i)^(-n)	
Options:	*CF 00: End mode*	*SF 00: Begin mode*
Variables Menu: LBL “TVM”		*Begin: p=0* *End: p=1*
Example. Given “End mode”, PMT = 650, n = 360, and I = 14.25% (yearly) Solves: PV = 53,955.91960		

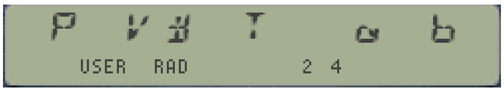
2. *Thermal & Transport Science equations.*

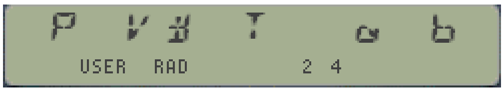
Bernoulli Equations.		
Equation:	dP/ρ + (V2^2 – V1^2).2 + g. dY = 0 (V2^2 – V1^2) = V1^2[(A1/A2)^2 -1]	
Options:	CF 00: n/a	SF 00: n/a
Variables Menus: LBL “BERN-A” LBL “BERN-V”	 	*Plus the density is prompted independently.* 
Example. Given P2 = 25 psi, P1 = 75 psi, Y2= 35 ft, Y1 = 0 ft, D2= 24 in, D1 = 18 in, r = 64 lb/ft^3, v1 = 100 ft/s. - Solves v2 = 122.4213 ft/s , A1= 254.4690 in^2, A2 = 452.3893 in^2		

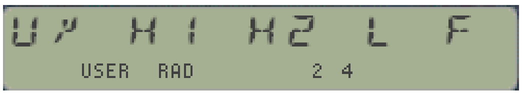
Isentropic Flow.		
Equation:	A/aT = (1/M).{[2/(k+1)].[1+(k-1).M^2/2] }^(k+1/k-1)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “ISENT”		*“M” needs custom guess*
Example. Given k=2, M=0.9 T0=26.85 C, T= 373.15 K, A= 1 cm^2 Solves: At=0.09928 cm^2		

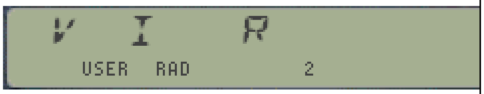
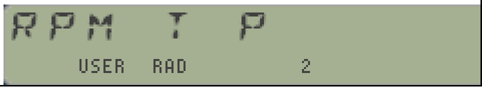
Real Gas Equation of State.		
Equation:	P.V = Z.n.R.T	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “PV=ZNT”		Z = Pr/Tr = P.Tc / Pc.T
Example. Given P= 5 kPa, V= 10 l, T = 25 °C, Z =0.161074 Solves: n = 0.125283 mol		

Heat Exchangers basic equation.		
Equation:	Q = k1 [T1(i)-T2(i)] / (1+ k12).{exp[–U.A.(1+k12) / k1] – 1 } Q = k1 [T1(i)-T2(o)] / (1– k12).{exp [–U.A.(1–k12) / k1] – 1 }	
Options:	*CF 00: Counter flow*	*SF 00: Parallel Flow*
Variables Menu: LBL "HEATX"	k1 = m1'.Cp1; k2 = m2'.Cp2 ; k12 = k1/k2 	*Plus a sixth variable prompted independently*: 
Example. Given a parallel flow with UA = 115.8185 kcal/°C.h ; k1 = 5 kcal/°C.min ; k2 = 7.7368 kcal/°C.min ; T1(i) = 20 °C; and T2(i)= 90 °C. Solves: Q = 5.999,998790 kcal/min		

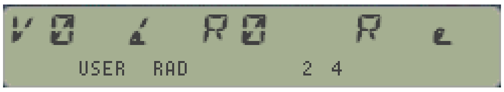
Van-der-Waals Equation of State.		
Equation:	P + (a/Vm^2) = RT /(Vm-b)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "VWAALS"		*V# is the molar volume* a = (27.R^2.Tc^2)/(64 Pc) b = (R.Tc)/(8 Pc)
Example. Given a = 14.66 ; b = 0.1226 ; P= 5 kPa, T = 25 °C, *and [a,b] = (1,5)* Solves: Vm = 0.614322294 m^3/mol		

Redlich-Kwong Equation of State.		
Equations:	P + a /[sqrt(T).Vm.(Vm+b)] = RT/(Vm-b)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "REDLCH"		*V# is the molar volume* a = 0.42747.R^2.Tc^2.5/Pc b = 0.086640.R.Tc/Pc
Example. Given a = 14.66 ; b = 0.1226 ; P= 5 kPa, T = 25 °C, *and [a,b] = (1,5)* Solves: Vm = 0.617958693 m^3/mol		

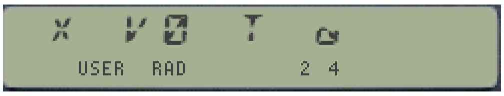
Michell Pad Hydrodynamic Lubrication.		
Equation:	Fr = [2 μ0.U0.L / (h1-h2)] [2 Ln(h1/h2) – 3 (h1-h2)/(h1+h2)]	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "MPAD"		μ0.U0 as a single input
Example. Given h1 = 0.5 mm, h2 = 0.1 mm, L = 4 cm, Fr = 5000 N Solves: μ.Uo. = 20.51070298		

Three-Variable Equations.		
Equations:	F= m.a ; V = I.R ; rpm = T.P	
Options:	CF 00: n/a	SF 00: n/a
Variables Menus: LBL "F=Ma"" LBL "V=IR"" LBL "RPM=TP"	  	rpm = ω . 2π/60
Example. Given F = 50 N, m = 2 kg , I = 2 A, R = 5 W, rpm = 3000, P = 5 wat Solves: a = 25 m/s^2; V = 10 V; T = 62.83185308 N.m		

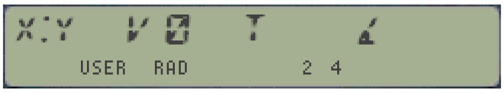
3. *Mechanics equations.*

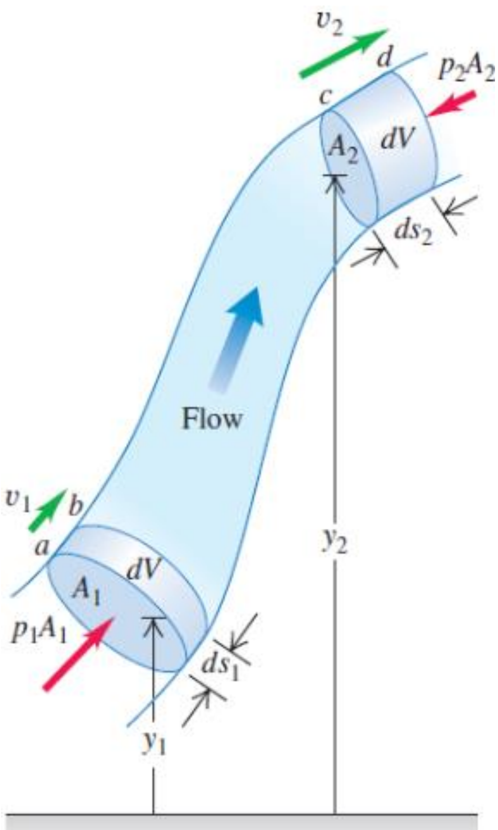
Orbital Launch Trajectories.		
Equation:	e = sqrt { 1 + [Vo^2 - 2g.(Ro2/r)].[r.Vo cos a / g.Ro]^2 }	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "ORBIT"		*"R" Needs custom guess*
Example. Given a = 15 deg, R0 = 6,000 km, R = 6,125 km, e = 0.25 Solves: V0 = 33.86842491 km/s		

Kepler's Orbital Equation.		
Equation;	E – ec. sin E = m	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "KEPLR"		*ec: is the eccentricity*
Example. Given ec = 0.2, and m = 0.8 Solves: E = 0.964333888		

Linear Motion Equation.		
Equation:	x = v0*t + (1/2)*a*t^2	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL "MVT"		
Example. Given x=100 m, t = 10 s, v0 =1 m/s, Solves: a = 1.8 m/s^2		

Universal Gravitation Law.		
Equation:	F = G.m1.m2/r^2	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “F=MMR2”		*“R” Needs custom guess*
<u>Example</u>. Given m1 = 2E15 kg, m2 = 2E18 kg, R= 1E6 km Solves: F = 266903.6 N		

Projectile Distance and Velocity.		
Equations:	X = Vo.t.cos θ ; Y = Vo.t.sin θ – (1/2) g.t^2 Vx = Vo.cos θ ; Vy = Vo.sin θ – g.t	
Options:	*CF 00: X-axis values*	*SF 00: Y-axis values*
Variables Menu: LBL “PRJT-D” LBL “PRJT-V”		
<u>Example</u>. Given θ = 45 deg, v0 = 200 ft/s, t = 10 s Solves: Vx = 141.4214 ft, Vy = 43.32135620 ft/s, X = 1,414.213562 ft, Y = 923.7135620 ft		

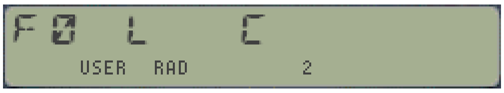


4. Electricity equations.

Serial RL AC Regulator Extinction angle.		
Equation:	sin $(\beta-\phi)$ exp[$\beta R/\omega L$] = sin $(\alpha-\phi)$ exp $(\alpha R/\omega L)$	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “SRL-AC”		$\omega = 2\pi.f$ Φ = atan $(\omega.L/R)$ α is the control angle, $-\pi <- \alpha < \pi$
Example: Given f = 50 Hz, R = 200 Ω, L = 1.1026 H, $\alpha = \pi/2$ rad, and [a,b] = (2, 4) Solves: β = 4.070404229 rad = 233.2169832 deg		

RLC Current Delay Angle.		
Equations:	tan ϕ = (XL – XC) / R ; tan ϕ =R.(1/XC - 1/XL)	
Options:	*CF 00: Serial*	*SF 00: Parallel*
Variables Menu: LBL “<)RLC”		XL = ω.L XC = 1/ω.C $\omega = 2\pi.f$
Example: Given f = 107 Hz, C=80 μF, L = 20 mH, R= 5Ω solves: Φ(serial) = –45.829157 deg , Φ(parallel) = –5.8773 deg		

Parallel Resistors association.		
Equation:	1/R = 1/R1 + 1/R2 (+ 1/R3)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “ΣPR”		*R3 is optional – must enter zero to ignore it.*
Example: Given R1 = 1 Ω, , R2 = 5 Ω, R3 =7 Ω Solves: ΣR = 0.744681 Ω		

Resonance Frequency RLC.		
Equation:	$\omega 0$ = 1 / sqrt(L.C)	
Options:	CF 00: n/a	SF 00: n/a
Variables Menu: LBL “MPAD”		$\omega 0 = 2\pi.f0$
Example: Given L = 500 mH, C= 8 μF, R= 10 Ω Solves f0 = 79.577472 Hz		