HP-35s Calculator Program –

TR55

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Line	Instruction	Process	User Instruction
T001	LBL T	Establishing the library (T goes for TR55)	Key in using EQN, RCL T, RCL I, etc
T002	TIME CONCENTR	Title: TR55 Time of Concentration	
T003	PSE	Pause	
T004	CLΣ	Clearing statistical data	
T005	CLVARS	Clear all variables	
T006	CLSTK	Clear Stack	
T007	OVLND SHEET FL		Nomenclature:
T008	PSE		
T009	INPUT Y		
T010	x=0?		
T011	GTO T042		
T012	ROUGH COEFF N		
T013	PSE		
T014	INPUT N	Input roughness coefficient	
T015	LENGTH FT		
T016	PSE		
T017	INPUT L	Input the length “L”	
T018	×		
T019	0,8		
T020	y^x		
T021	0.007		
T022	×		
T023	RAINF DEPTH IN	Depth of rainfall in inches	
T024	PSE		
T025	INPUT P		
T026	√x		
T027	÷		
T028	SLOPE (0.XX)		
T029	PSE	Pause	
T030	INPUT S	Input slope in digital format	
T031	0.4		
T032	y^x		
T033	÷		
T034	STO T		
T035	VIEW T	View time	
T036	Σ+		
T037	ADD ANOTHER		
T038	PSE		
T039	INPUT Y	“0” Rejects, all other values Accept	
T040	x≠0?		
T041	GTO T012		
T042	OVLND CONC FLO		
T043	PSE		
T044	INPUT Y		
T045	x=0?		
T046	GTO T084		
T047	LENGTH		
T048	PSE		
T049	INPUT L		
T050	SLOPE (0.XX)		
T051	PSE		
T052	INPUT S		
T053	IS IT PAVED?		
T054	PSE		
T055	INPUT Y		
T056	x=0?		
T057	GTO T062		
T058	RCL S		
T059	√x		
T060	20.3282		

A 300 acre watershed drains along the path ED→DC→CB→BA shown in the table below. Determine the time of concentration, t_c using SCS TR55 method

Hydraulic Path	Type of Flow	Slope (%)	Length (ft)
ED	Overland Sheet Flow	5.0	100
DC	Overland Gutter Flow (unpaved)	1.5	300
CB	Pipe Flow (d_0 = 24 in; n = 0.015)	1.0	3000
BA	Open Channel Flow (y = 2 ft; n = 0.02)	0.5	5000

(For a wide rectangular: Hydraulic Radius R = flow depth, y)

Note: The pipe is 24 inches in diameter with a Manning’s n = 0.015
The open channel is wide rectangular with main bank flow depth = 2.0 ft. and Manning’s n = 0.020.

1. Path ED (Overland Sheet flow):

T061	GTO T067
T062	UNPAVED
T063	PSE
T064	RCL S
T065	√x
T066	16.1345
T067	×
T068	STO V
T069	VELOCITY
T070	PSE
T071	RCL L
T072	INPUT V
T073	÷
T074	3600
T075	÷
T076	STO T
T077	VIEW T
T078	Σ+
T079	ADD ANOTHER
T080	PSE
T081	INPUT Y
T082	x≠0?
T083	GTO T047
T084	PIPE FLOW
T085	PSE
T086	INPUT Y
T087	x=0?
T088	GTO T122
T089	1.49
T090	MANNING N
T091	PSE
T092	INPUT N
T093	÷
T094	PIPE DIAM-FT
T095	PSE
T096	INPUT D
T097	4
T098	÷
T099	0.6666667
T100	y^x
T101	×
T102	SLOPE (0.XX)
T103	PSE
T104	INPUT S
T105	√x
T106	×
T107	1/x
T108	LENGTH (FT)
T109	PSE
T110	INPUT L
T111	×
T112	3600
T113	÷
T114	STO T
T115	VIEW T
T116	Σ+
T117	ADD ANOTHER
T118	PSE
T119	INPUT Y
T120	x≠0?
T121	GTO T089
T122	OPEN CHAN FLOW
T123	PSE
T124	INPUT Y
T125	x=0?
T126	GTO T159
T127	MANNING COEFF
T128	PSE

Bermuda Grass – roughness coefficient from slide 48, n = 0.43
2-yr, 24 hour cumulative rainfall depth, P_2 = 3.2 inches
Overland surface slope, S = 0.05
Overland flow length, L = 100 feet

From Equation $t = \frac{0.007(nL)^{0.8}}{P_2^{0.5}S^{0.4}}$

Travel time, $t_{ED} = \frac{0.007(nL)^{0.8}}{P_2^{0.5}S^{0.4}} = \frac{0.007(0.43x100)^{0.8}}{(3.2)^{0.5}(0.05)^{0.4}}$

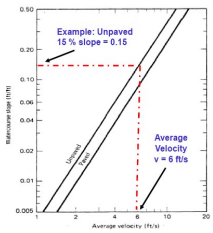
= 0.263 hrs = 15.8 min = 946.3 s

2. Path DC (Overland Concentrated Flow – Unpaved Surface):

Overland flow slope, S = 0.015
Overland flow velocity, V = 1.8 ft/s

Travel time, t_{DC} = L/V = 300/1.8 = 166.67 s = 2.78 min = 0.046 hrs.

Figure: SCS TR55 Average Velocity for Shallow Concentrated Overland Flow



3. Path CB (Pipe Flow):

Mannings, n = 0.015;
Pipe slope, S = 0.01;
Pipe length, L = 3000 ft
Pipe diameter = 24 inches = 2.0 feet
Pipe cross sectional area, A = 3.14x2²/4 = 3.14 ft²
Pipe wetted perimeter, P = 3.14x2 = 6.28 ft
Pipe Hydraulic Radius, R = A/P = 3.14/6.28 = 0.50
Velocity, V = (1.49/0.015)x0.5^{2/3}x0.01^{1/2} = 6.26 ft/s

$$Q = VA = \left(\frac{1.49}{n}\right)AR^{\frac{2}{3}}\sqrt{S}$$

Travel time in pipe, t_{CB} = L/V = 3000/6.26 = 479.2 s
= 7.987 min = 0.113 hrs

4. Path BA (Open Channel Flow):

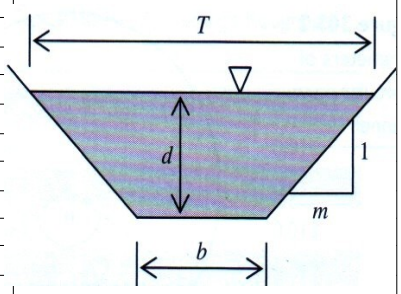
$$Q = VA = \left(\frac{1.49}{n}\right)AR^{\frac{2}{3}}\sqrt{S}$$

Mannings, n = 0.02; Channel slope, S = 0.005;
Channel length, L = 5000 ft
Flow depth, y = 2.0 feet
Hydraulic Radius, R = y = 2 feet (wide rect. channel)
Velocity, V = (1.49/0.02)x2.0^{2/3}x0.005^{1/2} = 8.36 ft/s

Travel time in pipe, t_{CB} = L/V = 5000/8.36
= 598.1 s = 9.968 min = 0.166 hrs

Watershed Time of Concentration, t_c = total travel time
= $\sum t = t_{ED} + t_{DC} + t_{CB} + t_{BA}$
= 0.263 + 0.046 + 0.113 + 0.166 = 0.588 hours = 35.28 min

T129	INPUT N		
T130	LENGTH		
T131	PSE		
T132	INPUT L		
T133	SLOPE		
T134	PSE		
T135	INPUT S		
T136	XEQ D004		
T137	INPUT R		
T138	0.666666667		
T139	y^x		
T140	RCL S		
T141	√x		
T142	×		
T143	1.49		
T144	×		
T145	RCL N		
T146	÷		
T147	1/x		
T148	RCL L		
T149	×		
T150	3600		
T151	÷		
T152	STO T		
T153	Σ+		
T154	ADD ANOTHER		
T155	PSE		
T156	INPUT Y		
T157	x≠0?		
T158	GTO T122		
T159	Σx		
T160	STO T		
T161	TOTAL HOURS		
T162	PSE		
T163	VIEW T		
T164	RTN		
		HYDRAULIC RADIUS	The following program is necessary for the above program to function. Both need to be installed for TP55 to function. However, Hydraulic Radius program can work by itself.
D001	LBL D	CLSTK	
D002	CLSTK	Clearing the stack	
D003	CLVARS	Clearing the variables	
D004	HYDRO RADIUS	Title	
D005	PSE	Short Pause	
D006	CIRCLE		
D007	PSE	Short Pause	
D008	INPUT H	Input 1 (or value ≠0 anyway) for Yes, 0 for No to Circle	
D009	x=0?		
D010	GTO R076	Takes you to option for straight walls	
D011	DIAMETER		
D012	PSE		
D013	INPUT D	Input the diameter of the circle	
D014	WATER DEPTH		
D015	PSE		
D016	INPUT H	Input the depth of the water	
D017	2		
D018	×		
D019	RCL D		
D020	÷		
D021	+/-		Nomenclature:
D022	1		
D023	+		A = Area of Flow
D024	ACOS		B = Base Width of Area of Water (see diag)
D025	2		D = Water depth
D026	×		H = Variable used for Yes/No 1/0 questions
D027	→RAD		M = Slope factor (see diag)
D028	STO Q		N = Manning's “n” Coefficient



D029	→DEG		P = Wet Perimeter
D030	SIN		Q = Flow
D031	RCL Q		R = Hydraulic Radius
D032	÷		S = Slope of Pipe
D033	+/-		T = Width of Water Surface
D034	1		V = Volume of Water to be Discharged
D035	+		Z = Hydraulic Depth
D036	4		
D037	÷		
D038	RCL D		
D039	×		
D040	STO R		
D041	INPUT R		
D042	×		
D043	-		
D044	+/-		
D045	RCL D		
D046	RCL Q		
D047	RCL D		
D048	×		
D049	2		
D050	÷		
D051	STO P		
D052	RCL Q		
D053	ENTER		
D054	→DEG		
D055	SIN		
D056	-		
D057	8		
D058	÷		
D059	RCL D		
D060	x^2		
D061	×		
D062	STO A		
D063	RCL D		
D064	RCL H		
D065	-		
D066	RCL H		
D067	×		
D068	√x		
D069	2		
D070	×		
D071	STO T		
D072	WIDTH FR SURFACE		
D073	PSE		
D074	VIEW T		
D075	GTO R125		
D076	STRAIGHT		
D077	PSE		÷
D078	INPUT H	Input 1 (or value ≠0 anyway) for Yes, 0 for No to Straight	
D079	x=0?		
D080	GTO R006		
D081	INPUT T	Input the width of the water surface (see diagram)	
D082	INPUT B	Input the base of the water (see diagram)	
D083	INPUT D	Input the depth of the water (see diagram)	
D084	2		
D085	×		
D086	1/x		
D087	RCL T		
D088	RCL B		
D089	-		
D090	×		
D091	STO M		
D092	VIEW M	Viewing slope factor m (see diagram)	
D093	RCL D		
D094	×		
D095	RCL B		
D096	+		

D097	RCL D		
D098	×		
D099	STO A		
D100	CLSTK		
D101	RCL M		
D102	x^2		
D103	1		
D104	+		
D105	√x		
D106	2		
D107	×		
D108	RCL D		
D109	×		
D110	RCL B		
D111	+		
D112	STO P		
D113	CLSTK		
D114	RCL A		
D115	RCL P		
D116	÷		
D117	STO R		
D118	RCL A		
D119	RCL T		
D120	÷		
D121	STO Z		
D122	HYDRO DEPTH		
D123	PSE		
D124	VIEW Z	Viewing Hydraulic Depth	
D125	AREA OF FLOW		
D126	PSE		
D127	VIEW A	Viewing Area of Flow	
D128	WET PERIMETER		
D129	PSE		
D130	VIEW P	Viewing Wet Perimeter	
D131	HYDRO RADIUS		
D132	PSE		
D133	VIEW R	Viewing the Hydraulic Radius	
D134	CLSTK		
D135	STO H		
D136	CALCULATE FLOW		
D137	PSE		
D138	INPUT H	Input 1 (or value ≠0 anyway) for Yes, 0 for No	
D139	x=0?	to calculate the flow	
D140	GTO R175		
D141	MANNING COEFF		
D142	PSE		
D143	INPUT N		
D144	1/x		
D145	149		
D146	×		
D147	RCL R		
D148	0.6666666667		
D149	y^x		
D150	×		
D151	RCL A		
D152	×		
D153	SLOPE (0.XXX)		
D154	PSE		
D155	INPUT S	Input the slope in decimals	
D156	√x		
D157	×		
D158	STO Q		
D159	VIEW Q	Viewing flow	
D160	TIME DISCHARGE		
D161	PSE		
D162	INPUT H	Input 1 (or value ≠0 anyway) for Yes, 0 for No	
D163	x=0?	to calculate the time of discharge	
D164	GTO D175		

D165	VOLUME TO FILL		
D166	PSE		
D167	INPUT V	Input the volume to fill	
D168	RCL Q		
D169	÷		
D170	3600		
D171	÷		
D172	STO T		
D173	VIEW T	Viewing the time to discharge the volume	
D174	CLSTK		
D175	RTN		

y^x
x^2
√x
÷
×
x≥y?
R↓
x≤y?
x≠0?

y^x
x^2
√x
÷
×

x≥y?
R↓
x≤y?
x≠0?