HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Energy Conservation



INTRODUCTION

In an effort to provide continued value to it's customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program solutions — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Program Listing I** and Program Listing I and Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.

REMEMBER! To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

TABLE OF CONTENTS

AIR COOLING SYSTEM DESIGN Program calculates one of any four quantities in the design of an 1 air cooling system for electronic equipment. Given the ambient temperature, the power dissipation in the enclosure, and the worst case maximum temperature, the program calculates the required blower rating in cubic feet per minute. BLACK BODY THERMAL RADIATION Calculates wave length of maximum emissive power, total emissive 6 power, monochromatic emissive power, emissive power from zero to a specified wave length, for black radiating surfaces. ECONOMIC INSULATION THICKNESS Can be used to determine the economic thickness of insulation . . . 14 given the thermal properties of the insulation, the cost of energy, hours of operation, cost of insulation, and the temperature difference. 18 . composite tubes and walls from individual section conductances and surface coefficients. STEADY STATE COND. HEAT TRANS., HEAT LOAD & LOGARITHMIC MEAN TEMP DIFF. 23 . Computes heat duty, heat load, transfer area, logarithmic mean temperature difference, heat capacity, transfer coefficient and mass flow rate. SUN ALTITUDE, AZIMUTH, SOLAR POND ABSORPTION Computes sun's altitude, azimuth, and the fraction of the sun's 27 radiation which will penetrate the surface of a solar pond given index of refraction of pond fluid, latitude, number of days after spring equinox, and number of hours before or after solar noon. TOTAL DAILY AMOUNT OF SOLAR RADIATION Computes length of day and total amount of solar radiation received 31 by a horizontal surface of unit area as a function of latitude and declination of the sun. TEMPERATURE OR CONCENTRATION PROFILE FOR A SEMI-INFINITE SOLID May be used to find the temperature (or concentration profile) at . . 35 a specified time for a semi-infinite solid with constant surface temperature (or concentration) the profiles is assumed to be uniform when time equals zero.

IRANSIENI	IEMPE	RATURE	DISI	RIB	0110	ON I	NA	SE	M I -	INF	· I N I	ITE	SC	JLI	[D				1.0
WITH	CONVE	CTION E	BOUNE	ARY	C01	NDIT	ION												40
Comput	ces fac [.]	tor enab	ling	calc	ulat	tion	of t	emp	erat	ure	in	as	sem	i-					
		id for d													the	erm	la 1		
		, therma																	
conduc	,	, cherma		1431	1103	, un	u ne	uc	un un	310		Jera	i i c	ren					
CONSERVATI			,																ЦЦ
CUNSERVALL		ENEKGI																	77

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Program Title	Air Cooling Sys	tem Design						
Contributor's Name	Hewlett-Packard							
Address	1000 N.E. Circle Blv	/d.						
	orvallis	State	Oregon	Zip Code	97330			
<u></u>								
Program Description,	Equations, Variables							
Define: H _i	<pre>= Molal enthalpy of a</pre>	air at T _i ar	nd P _i (BTU/LI	B Mole)				
	= Power in kilowatts							
T,	= Temperature in degr	rees Rankine	e (°R)					
Ŷ,	= Volumetric flow rat	ce						
. '	= Molal flow rate							
1	itside enclosure	p; = p	pressure (in	atmospheres)				
i = 2 for ir	side enclosure	•			pressure =			
<pre>i = 2 for inside enclosure C_p = specific heat at constant pressure =</pre>								
- Molar volume for air at a temperature T and pressure p is $V = (0.35905)$								
	10 ³ Ft ³ /1b-mole) (At							
	ance at steady state							
•	$-P_{2}) = H_{2}N_{2}$							
		C1	, <u>,</u> ,p	2, 7, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,				
- Molal volu	me for an ideal gas h	has a flow h	rate $V_1 = (\frac{1}{p})$	$\frac{1}{1} \frac{1}{1} \frac{1}{2}$				
- Specific ł	neat equation H ₂ - H ₁	= c _p (T ₂ ·	- T ₁)					
- Neglect pr	ressure difference p _i	i = p ₂						
		-	Continue	d on next page	→			
Operating Limits and \	Varnings				,			
1. Calculat	ion assumes steady st	tate, treats	s air as an	ideal gas, neg	lects			
humidity	-			•				
-	key should not be use	ed as it com	ntains sever	al values neede	ed to			
	program into the lin							

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

NEITHER HP NOR THE CONTRIBUTOR MAKES ANY EXPRESS OR IMPLIED WARRANTY OF ANY KIND WITH REGARD TO THIS PROGRAM MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NEITHER HP NOR THE CONTRIBUTOR SHALL BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH OR ARISING OUT OF THE FURNISHING, USE OR PERFORMANCE OF THIS PROGRAM MATERIAL.

Program Title	Air Cooling System Design					
Contributor's Na Address	me Hewlett-Packard 1000 N.E. Circle Blvd.					
City	Corvallis	State	Oregon	Zip Code	97330	

Program Description, Equations, Variables

$$\frac{\text{Then}}{V_2} \dot{V}_2 = \frac{K(P_2 - P_1)T_2}{T_2 - T_1} = Ft^3/\text{min} = \text{Req'd flow rate } k = 5.974$$

$$\frac{\text{or}}{V_2} P_2 P_1 = \frac{\dot{V}_2}{k} \left(\frac{T_2 - T_1}{T_2}\right) = kW = \text{Power Input}$$

$$\frac{\text{or}}{T_2} = \frac{\dot{V}_2 T_1}{V_2 - k(P_2 - P_1)} = \text{Max. Enclosure Temperature}$$

or
$$T_1 = \frac{I_2}{V_2} (V_2 - k(P_2 - P_1)) = Ambient Temperature$$

Operating Limits and Warnings

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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72[A] 85[B] 250[C] [D]	0.9982	
[D] 68[A] [C]	191.1765	
200[C] 1[D] [A]	68.7209	
65[A] [B]	81.1646	

Reference(s) V.M. Faires, Thermodynamics, 5th Edition, MacMillan Co., New York, 1970; page 453.

This program is a translation of the HP-65 User's Library program #02001A submitted by Todd A.C. Heard.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Enter any three of the four variables in any order using the designated keys.			
2.	Do not use the"E" key. If you do by mistake,			
	just re-enter all the values again.			
3.	Enter ambient temperature.	T _l (°F)		°F
4.	Enter max temperature for the enclosure.	T ₂ (°F)	[B] []	°F
5.	Enter volumetric flow rate of air cooling system.	V(Ft ³ /min)		Ft ³ ∕min
6.	Press and get max power (kW) that can be		[] []	KW
	dissipated in the enclosure.			
	NOTE:			
	1) If you wish to change any of the input			
	variable to see its affect on the calculati key in the new value and press the key for	on,		
	the unknown.			
	 As the variables may be keyed in in any order the result may be considered as an input and new values can be calculated 			
	with one of the input variables becoming			
	the unknown.			
				······································

97 Program Listing I

			// i logi am				5
STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11		857	*LBLD	21 14	
802		35 01		058	ST04	35 04	
002				859	Ø	00	1
004 004		00 16 70		860	X≠Y?	16-32	
805		16-32		861	RTN	24	
886 886		24 23-15	Calls constants,etc	862	GSBE	23 15	1
007				063	RCL5	36 05	1
		36 04 36 04		864	RCL3	36 03	1
800 800		36 86		065	x	-35	1
009		-22		866	RCL5	36 06	1
610		36 03 55		867	÷	-24	1
611	+	-55		868	ENT†	-21	1
812		36 03		869	RCL8	36 0 8	Computed P _{1N} (kW)
013		-24		070	÷	-24	
014		-21		671	RTN	24	
015		36 08	Computed t ₁ (°F)	072	*LBLE	21 15	1
016		-35		073	5	0 5	1
017		36 07 45	1	874		-62	Constant 5.974
618		-45		875	9	89	
019		24	1	076	9 7	07	1
020		21 12		877	4	84	
021	ST02	35 02		678	ST06	35 06	
022		00		879	4	84	Constant 160
023		16-32		080	6	0 6	Constant 460
024		24		881	e	80	
025		23 15		082	ST07	35 07	
0 26		36 01		083	RCL2	36 02	
027		36 07		884	RCL1	36 01	
028		-55		085	-	-45	$(t_{-}-t_{-})$
029		36 03		88 6	ST05	35 05	(t ₂ -t ₁)
030		-35		087	RCL2	36 8 2	
031		-21		888	RCL7	36 87	
032		36 04		689	+	-55	T ₂ (°R)
833		36 06		090	ST08	35 0 8	2 12
834		-35		091	RTN	24	
035		-22				 	•
036		36 03		\vdash		···-	-
837		-55					4
638		-24	Computed t ₂ (°F)	├ ─── ├			4
839		36 07	2	\vdash			4
840		-45		├ ──┤		<u> </u>	4
041	RTN	24		├ ──┼			1
<i>042</i>		21 13		├ ──┤		<u> </u>	1
843		35 0 3	1	100		 	4
044		0 0				 	4
045		16-32		┝		 	4
846	RTN	24		┣───┣		 	4
847		23 15		┣───╂		<u> </u>	4
048		36 08		┝──┼		<u></u>	4
849		36 04		┝──┼		+	
050		-35		┢──┼		╂╌╋	SET STATUS
051	RCL6	36 06		┣───┤		FLAGS	TRIG DISP
0 52		-35		┣∔		ON OFF	
053		-21	1	110			DEG Ø FIX Ø GRAD □ SCI □
054 055		36 05	Computed V (Ft ³ /min)	⊢			GRAD I SCI I RAD I ENG
055		-24	Jomputea V (Ft/min)		•		
0 <u>56</u>	RTN	24	DECI	STERS			
0	1 . (0-	2		5	6	7 400	8 T (9D) 9
ľ	¹ t ₁ (°F) ² t ₂ (°F) $\frac{3}{V}$ (FT ³ /min) $\frac{4}{P}$ 1N (kW)	⁵ t ₂ -t ₁	⁶ 5.974	/ 460	⁸ T ₂ (°R) ⁹
S0	S1	S2	S3 S4	S5	S6	S7	S8 S9
A		B	c	D	_	E	1

<u> </u>					
Program Title B	lack Body Thermal Radiat	ion			
Contributor's Name	Hewlett-Packard				
Address	1000 N. E. Circle Blvd.	•			
City	Corvallis	State 0	regon	_Zip Code	97330
Program Description	, Equations, Variables Bodies with finite tempera the absolute temperature,		al radiation. The higher		
	Bodies which emit the max wavelength for a specified	imum possible arr	ount of energy at every	/	
	While black bodies do not may be assumed to be black			s	
	1	λ_{\max_1}			
	Black body monochromatic	λ_{max_2}	T ₁ • T ₂ • T ₃		
Ne Mar Had I I TIMI	emissive power	··max ₂		NA POPPARAMINE A VAL	
		λ _{max3}		-	
the second to be	/		JJJ		
	1 2	3 4 5	6 7 8		
Operating Limits and		velength, microns Figure 1.	3	•	tinued t page)
	or more may be required	to obtain E	b(0-λ) or E _{b(λη} -	·λ ₂) sinc	e the
	on is numerical.			L :	
Sources d	iffer on values for cons	stants. This	could yield sma	<u>11 discr</u>	epancies
between p	ublished tables and prog	gram outputs	•		
	· · · · · · · · · · · · · · · · · · ·				
<u> </u>					
this program material upon any representation	a verified only with respect to the num AT HIS OWN RISK, in reliance solely on or description concerning the prog	y upon his own ins gram material.	pection of the program	material and	without reliance
PROGRAM MATERIAL	E CONTRIBUTOR MAKES ANY EXPR ., INCLUDING, BUT NOT LIMITED TO PURPOSE. NEITHER HP NOR THE C DNNECTION WITH OR ARISING OUT), THE IMPLIED W ONTRIBUTOR SH	ARRANTIES OF MERCI	HANTABILITY CIDENTAL O	AND FITNESS

Figure 1 is a representation of black body thermal emission as a function of wavelength. Note that as temperature increases, the area under the curves (total emissive power $E_{b(0-\infty)}$) increases. Also note that the wavelength of maximum emissive power λ_{max} shifts to the left as temperature increases.

This program calculates the wavelength of maximum emissive power for a given temperature, the temperature for which a given wavelength would be the wavelength of maximum emissive power, the total emissive power over all wavelengths, the emissive power at a particlular wavelength, the emissive power form zero to a specified wavelength, and the emissive power between specified wavelengths.

Equations:

$$\lambda_{\max} T_{\lambda_{\max}} = c_3$$

$$E_{b(0-\infty)} = \sigma T^4$$

$$E_{b\lambda} = \frac{2\pi c_1}{\lambda^5 (e^{c_2/\lambda T} - 1)}$$

$$E_{b(0-\lambda)} = \int_0^{\lambda} E_{b\lambda \ d\lambda}$$

$$= 2\pi c_1 \sum_{k=1}^{\infty} -T/kc_2 \ e^{-\frac{kc_2}{T\lambda}} \left[\left(\frac{1}{\lambda}\right)^3 + \frac{3T}{\lambda^2 kc_2} + \frac{6}{\lambda} \left(\frac{T}{kc_2}\right)^2 + 6\left(\frac{T}{kc_2}\right)^3 \right]$$

 $E_{b(\lambda_1 - \lambda_2)} = E_{b(0 - \lambda_2)} - E_{b(0 - \lambda_1)}$

where

 λ_{max} is the wavelength of maximum emissivity in microns;

T is the absolute temperature in $^{\circ}R$ or K;

 $E_{b(0-\infty)}$ is the total emissive power in Btu/hr-ft² or Watts/cm²;

- $E_{b\lambda}$ is the emissive power at λ in Btu/hr-ft²- μ m or Watts/ cm²- μ m;
- $E_{b(0-\lambda)}$ is the emissive power for wavelengths less than λ in Btu/ hr-ft² or Watts/cm²;
- $E_{b(\lambda_1 \lambda_2)}$ is the emissive power for wavelengths between λ_1 and λ_2 in Btu/hr-ft² or Watts/cm².
 - $c_1 = 1.8887982 \times 10^7 \text{ Btu-}\mu\text{m}^4/\text{hr-ft}^2$
 - $= 5.9544 \times 10^3 W \mu m^4 / cm^2$
 - $c_2 = 2.58984 \times 10^4 \ \mu m^{-\circ} R = 1.4388 \times 10^4 \ \mu m^{-K}$
 - $c_3 = 5.216 \times 10^3 \ \mu \text{m}^{-6} \text{R} = 2.8978 \times 10^3 \ \mu \text{m}^{-K}$
 - $\sigma = 1.713 \times 10^{-9} \text{ Btu/hr-ft}^2 \text{ }^{\circ}\text{R}^4 = 5.6693 \times 10^{-12} \text{ W/cm}^2 \text{-K}^4$
 - $\sigma_{exp} = 1.731 \times 10^{-9} \text{ Btu/hr-ft}^{2} \cdot R^{4} = 5.729 \times 10^{-12} \text{ W/cm}^{2} \cdot \text{K}^{4}$

Sketch(es)	
	· · · · · · · · · · · · · · · · · · ·
	ter a ser a se
	· · · · · · · · · · · · · · · · · · ·
Sample Problem(s) <u>Example 1</u> :	
What percentage of the rad	iant output of a lamp is in the visible range (0.4
to 0.7 microns) if the fila	ament of the lamp is assumed to be a black body
at 2400 K? What is the perc	
	-
Keystrokes:	Outputs:
	$5.669 \times 10^{-12} \text{ W/cm}^2 \text{-K}^4$
2400 [A] .4 [B] .7 [f] [E]	[C] [÷] 100 [x]→ 2.641%
2500 [A] .7 [f] [E] [C] [÷]] 100 [x]
Example 2:	
·	· · · · · · · · · · · · · · · · · · ·
-	ned to work most efficinetly is sunlight and the
visible spectrum runs from	about 0.4 to 0.7 microns, what is the sun's
temperature in degrees Rank	kine? Assume that the sun is a black body. Using
	, find the fraction of the sun's total emissive
	isible range. Find the percentage of the sun's
radiation which has a wave	length less than 0.4 microns.
Keystrokes:	Outputs:
	$1.713 \times 10^{-9} \text{ Btu/hr-ft}^2 - \text{°R}^4$
Compute mean of visible rar	· · · · ·
-	-
	550.0 x 10 ⁻³ µm
Compute temperature of sun.	
[B]	9.484 x 10 ³ °R
(continued)	
(contrinueu)	
Reference (s)	
	ohn R. Howell, Thermal Radiation Heat Transfer,
VOIUIIC 1, INACIONAL	Aeronautics and Space Administration, 1968.

User Instructions

Black Body 1	hermal Rad	diation		-
Eng	SI	Exp σ		λ'→E _b () , , ,)
$\mathbf{E} = \mathbf{T} \rightarrow \lambda \mathbf{max} =$	λ→ T(λma)	()_→E _b (₀ -∞)	-→E bλ	$E_{b(0-\lambda)}$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Store constants:			
	For English units (Btu, μm, hr, ft, °R)			1.713×10^{-9}
	For SI units (W, µm, cm, K)			5.669x10 ¹²
3	For experimental Stefan-Boltzman constant			1.731x10 ⁻⁹
	instead of theoretical value press			or 5.729x10 ¹²
4	Calculate any or all of the following (T and			5./29x10
	λ need only be input once):			
	A need only be input once/.			
	Calculate λ_{max} for a given T;	Т		λ _{max}
	max			
	Calculate T such that λ is λ_{max} for T;	λ		$T(\lambda_{max})$
		-		
	Calculate total emissive power;	Т		Е _{b(0-∞)}
	Calculate the emissive power at λ ;	T		
		λ	BD	λ E _{bλ}
	Calculate the emissive power between zero			
	and λ ;	Т		λ max
		λ		E _{b(0-λ)}
	Calculate the emissive power between λ			
	and λ' .	T		λ The has had been a second s
		$\frac{\lambda}{\lambda'}$		F T(^max)
		<u>л</u>		<u> ⁻ b(λ-λ')</u>
5	For a new case, go to steps 2, 3, or 4.			
	· · · · · · · · · · · · · · · · · · ·			

Program Listing I

12			// Flugian		iiig i	,		
STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	~~~	
861		15 11		- 057	5	05	CO	MMENTS
002					<u>_</u>			
	1	01	Store English	858	•	-62		
003	8	Ø8	constants.	659	6	06		
804	8	68		060	6	06		
005	8	68		061	9	09		
006	8 7	07		062	3	03		
007							l l	
	9	09		863	EEX	-23		
008	8	<i>08</i>		864	CHS	-22		
009	2	02		065	1	01		
010	ST01	35 01		066	2	02		
811	2	02		867	ST04	35 04		
	2 F						1	
012	5	05		068	RTN	24		
013	S	08		069		16 13	Convert	to exper-
814	9	09		070	1	01		
015	8	08		871		-62	imental	σ.
016	-	-62		872	Ø	00		
	•				e.			1
017	4	64		073	1	01		1
018	ST02	35 02	1	874	0	00		
019	5	05	1	075	5	05		
020	2	02	1	876		-35 04		
021		01 01	1	070	RCL4 53	36 04		
	4 /*		1				Store T	and cal-
822	6	06		078	RTN	24	culate)	
023	ST03	35 03		079	*LBLA	21 11	culate λ	max'
824	•	-62		080	ST05	35 05		
025	1	Ū1		081	RCL3	36 03		
026	7	07		082	XZY	-41		
027	4				÷			
	<u>+</u>	Ø1		683		-24		
028	3	03		084	RTN	24		
829	1	01		085	*LBLB	21 12		
030	2	8 2		086	ST06	35 06		and calcu- 📔 🌒
031	EEX	-23		087	RCL3	36 03	late T fo	or which 📔 🔽
032	CHS	-22		688	X≠Y	-41	λ would I	he l
							/ would i	^max•
833	ε	08		689	÷	-24		
834	STO4	35 04		090	RTN	24		
035	RTS	24		091	*LBLC	21 13	C_{2} C_{2	e E _{b(0-∞}).
036	*LBLb 21	16 12		092	RCL5	36 05	Carculace	⁼ ⁻ b(0-∞) ·
037	5	05	Store SI constants.	093	X2	53		
038	9		score si constants.					
	_	09		094	X2	53		
039	5	05		095	RCL4	36 04		
040	4	04		896	X	-35	1	1
041		-62		097	RTN	24		
042	4	04		898	*LBLD	21 14		
843		35 01				21 17		
	4			899	RCL1	36 01	Calculate	e E
844	÷.	01		100	ENTT	-21		¯Dλ
045	4	Ø4		101	+	-55	i.	
046	3	03		102	Pi	16-24		1
847	8	0 8		103	×	-35		
048	8	08		104	RCLE	36 06		
849		35 02						
				105	.5	05 5	-	
850	2	02		106	Υ×	31		1
851	8 9	88		[107	÷	-24		
852	9	09		108	RCL2	36 02		
85 3	7	09 07		109	RCL6	36 06		
854	-	-62		110	÷	-24		
855	ε	8 8						
				111	RCL5	36 05		
856	STO3	35 03 L		112	÷	-24	<u></u>	
				STERS				
ο λ		2	3 6 4	⁵ T	6	7	8 KG /T	9
	C1	c ₂	C 3 σ		λ, λ'	sum	kc ₂ /T	
S0	S1	S2	S3 S4	S5	S6	S7	S8	S9
						1	1	
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97 Program Listing II

			7/ 1105					
STEP	KEY ENTRY	KEY CODE	COMME	NTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
113	e*	33			169		16-35	
114	4	Ŭ1 45			170		22 01	
115	-	-45			171	R4	-31	
116	÷ dtv	-24 24			172	CLX	-51	
117	RTN +I RI E	21 15	Calculate E		173	RCL7	36 07	
118 113	≉LBLE 0	21 15 00		b(0-λ)'	174	ENTT	-21	
120	STO8	35 08			175	+	-55	
120	ST08 ST07	35 07 35 07			176		16-24	
122	*LBL1	21 01			177		-35	
122	RJ	-31			178		36 01 75	
123	CLX	-51			179		-35	
125	RCLE	36 08			190		24	
125	RCL2	36 02			181		21 16 15	Calculate $E_{b(\lambda-\lambda')}$
120	RCL5	36 05			182		-21	
123	÷	-24			183		-21	
129	-	-45			184		23 15 -41	
130	STOS	35 08			185			
130	3100	03 03			186		36 06 35 00	
131	X#Y	-41			187		33 00 -31	
132		-24			188		-31 35 06	
133	RCL6	36 86			189 190		35 06 23 15	
135	XS	53					-45	
136	÷	-24			191 192		16 31	
137	LSTX	16-63			192		36 00	
138	1/X	52			193		35 06	
139	RCLE	36 06		i	194		-31	
140	÷	-24			195		24	
141	-	-45	;		130	<u></u>	1 27	
142	ε	86						4
143	RCLĒ	36 06						4
144	÷	-24			200			-
145	RCLS	36 08					1	4
146	×2	53					+	1
147	÷	-24					1	1
148	-	-45						1
149	6	06						1
150	RCLS	36 8 8						1
151	Xs	53					1	1
152	÷	-24						
153	RCL8	36 08						1
154	÷	-24			210			1
155	+	-55]
156	RCL8	36 08]
157	RCLE	36 06]
158	÷	-24]
159	e×	33						
160	×	-35						
161	RCL8	36 08				-]
162	÷	-24	1]
163		5-55 07]
164	RCL7	36 0 7			220			1
165	÷	-24					<u> </u>	4
166	EEX	-23						4
167	CHS	-22			\vdash		+	4
168	5	05				EL AGO	1	
A	<u>Ів _ (</u>		LABELS	F		FLAGS		SET STATUS
	[™] λ+T($(\lambda_{max}) \xrightarrow{C \to E}_{c} b$	(A L →E	<u>, [+</u>		Ľ	FLAGS	TRIG DISP
Eng	b SI			^ e, i	5 , 0 - 7	1	ON OFF	DEG 🔽 FIX 🗆
Eng 0	<u> </u>	[°] Exp	3		≯⊏ b(λ=λ	2		DEG D FIX D GRAD SCI
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5	6 - ()	7	8	9		3		n_3_
	1			B				- · · · · · · · · · · · · · · · · · · ·

Program Title Economic Insula	tion Thickness	· · · · · · · · · · · · · · · · · · ·		
		· · · · · · · · ·		
Contributor's Name Hewlett-Packa	rd			
Address 1000 N.E. Circl	e Blvd.			the state of the second state
City Corvallis	State (Oregon	Zip Code 9	7330
Program Description, Equations, Variables		an a		
$I = 3.46 \times 10^{-3} \sqrt{Y(\Delta T) M}$	k/b -6k	• • • • • • • • • • • • • • • • • • •		
Where:				
I = thickness of insulation	n in inches			
Y = hours per year	· · · · · · · · · · · · · · ·			**************************************
k = conductivity of insulat	tion BTU/ft ² °F/ft.	1 / 1 / 197 / data 46 in fai internet tan in internet interne		and the second second second
$\Delta T = temperature difference$	and the second			
M = cost of energy \$ per 1(🖌 👝 martina da la companya da la			
b = cost of insulation \$ pe		knoco		
		KIIESS		
			1. 18. 1990 (17.1. 1. A.)	
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·		·····	1999 1988 2000-000 1000 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
			<u></u>	
Operating Limits and Warnings				· · · ·
				· · · · · · · · · · · · · · · · · · ·
Insulation is assumed to be	protected from mo	isture saturat	ion possibili	ties.
				0.001
This program has been verified only with respect this program material AT HIS OWN RISK, in re upon any representation or description concern	liance solely upon his own ir	viven in <i>Program Desc</i> respection of the prog	cription II. User acce ram material and wi	epts and uses thout reliance
NEITHER HP NOR THE CONTRIBUTOR MAKES PROGRAM MATERIAL, INCLUDING, BUT NOT FOR A PARTICULAR PURPOSE. NEITHER HP TIAL DAMAGES IN CONNECTION WITH OR AF MATERIAL.	LIMITED TO, THE IMPLIED IN NOR THE CONTRIBUTOR SI	WARRANTIES OF MI HALL BE LIABLE FOI	ERCHANTABILITY A	ND FITNESS

•

Sketch(es)	
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	e e e e e e e e e e e e e e e e e e e
Sample Problem(s)	
A. What thickness of insulation is economic f	or a pretad wall used in a structure
with the following conditions?	
$k = 0.15, \Delta T = 72^{\circ}-32^{\circ}F$	
Y = 24 hrs per day per year(87	60),
$M = $1.00 \text{ per } 10^6 \text{ BTU}$	· · · · · · · · · · · · · · · · · · ·
b = \$0.20 per sq. ft. per inch	thickness
B. What if the energy price is \$2.50/million	BTU?
19 A	
Solution(s)	
0.15 [+] 8760[B] 40[C] 1[D] 0.2[E] [A] [R/:	S]> 0.87 inches
A Ans. 0.87 inches	
2.5[D] [A] [R/S]	> 1.90
B Ans. 1.90 inches	· · · · · · · · · · · · · · · · · · ·
	· · · ·
	·· · · · · · · · · · · · · · · · · · ·
	· · · · · · · · · · · · · · · · · · ·
Reference(s) Mechanical Engineers Handbook, L. N	Marks, McGraw-Hill 1941, pg 404.
This program is a travelation of the second	
This program is a translation of the HP-65	Users' Program #01621A submitted
by John R. Feemster.	

a

User Instructions

1	Economic Insulation Thickness	7
J in.	k↑ Yhr/yr △T°F \$/10 ⁶ BTU \$/Inch Ins	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Input program			
2.	Input data			
	<u> </u>	BTU/hr°F/ft		k
	Y	hr/yr		k
	ΔΤ	°F	C	°F
2	Any two of the following over the			
3.	Any two of the following are entered			
	<u>I</u>	inches		inches
	\$/10 ⁶ BTU \$/inch ins.	\$		\$\$
	4/ Inch Ins.	\$		\$
	0-1-1-1			
_4	Calculate		A R/S	inches
	\$/10 ⁶ BTU			\$
	\$/inch ins.		E R/S	\$
				Ψ
5.	To begin new problem begin at step 2			
	·			
			have a second sec	

STEP KEY ENTRY KEY CODE COMMENTS STEP KEY ENTRY KEY CODE COMMENTS 061 4ELA 21 4 4 4 510 35 4 4 4 65 5 7 4 65 85 87 24 4 667 8 661 5107 75 67 8 661 5107 75 67 8 661 5107 75 67 661 5107 35 661 8 663 8 7 36 667 8 667 8 6 6 6 6 6 6 6 6 6 6 6 6 6 7 35 6 7 6 7 7 6 7 7 6 7 7 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7				97 Pro)gram	Lis	ting I	:		17
abs://abs bb/s b/s b/s	STEP	KEY ENTRY	KEY CODE	COMM	IENTS			KEY CODE	COMMEN	NTS
ability of the second secon										
⁶ / ₁ · · · -22 Const. 3.46 x 10 ⁻³ ⁶ / ₁ · · · · · · · · · · · · · · · · · · ·										1
θes 4 44 64 Const. 3.46 x 10 ⁻⁰ 661 STO7 37 67 62 R/2 5 7 Calculate b 066 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6		3								
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θ67 FEE -23 θ63 RCL2 36 62 θ68 0 -22 0 65 KCL2 36 66 θ69 CH2 -22 0 665 KCL2 36 68 θ19 STO 25 66 RCL3 36 64 θ11 RCL2 36 87 x -35 θ14 RCL2 36 86 87 x -35 θ14 RCL2 36 87 x -35 θ14 RCL2 36 87 x -35 θ16 RCL2 36 87 x -35 θ18 RCL2 36 97 87 x -35 θ18 RCL2 36 97 87 87 24 θ21 x -35 97 87 87 97 θ21 x -35 97 87 97 <					0 × 10				Calculate b	• I
θeg T 2 32 864 RCL5 36 85 86 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>ľ</td><td>1</td></th<>									ľ	1
θθρ CH2 -22 θ65 × -35 θ10 STOC 35 65 866 867 × -35 θ12 RCL2 36 867 × -35 970 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 871 872 873 -35 873 875 875 875 875 875 875 875 875 876 879 877 35 879 877 35 879 877 35 879 877 35 879 877 35 879 877 35 879 877 37 37 37 37 37 37 37 37 37 37 37 37 37 37 37 37 37 <										ł
100 5106 25 ac 066 RCL4 36 ac 011 RCL1 36 bl 066 RCL3 36 bl 36 bl 011 RCL2 36 bl 070 RCL1 36 bl 070 015 RCL3 36 bl 070 RCL1 36 bl 070 015 RCL4 36 bl 071 75 bl 070 RCL1 36 bl 017 RCL3 36 bl 071 RCL1 36 bl 070 RCL1 36 bl 018 RCL4 36 bl 073 RC15 36 bl 071 75										
a) 11 RCL1 36 a) BC7 x 35 B(12 RCL2 36 a) BC8 RCL3 36 a) B(13 RCL3 36 a) BC9 N 35 B(14 RCL3 36 a) BC9 N 35 BC1 S6 a) B(15 X 35 BC1 S6 a) BC1 S6 a) B(15 X 35 BC1 S6 a) BC1 S6 a) B(15 X 35 BC1 S6 a) BC1 S6 a) B(15 X 35 BC1 S6 a) BC1 S6 a) B(16 RCL4 S6 a) BC7 X 35 BC1 S6 a) B(16 RCL5 S6 b) BC7 K 55 BC7 K C C C B(20 RCL3 S6 b) BC7 K S7 b) BC7 S7 b) BC7 <										
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θ14 RCL3 36 83 θ15 × -35 θ16 RCL4 36 84 θ17 × -35 θ18 RCL5 36 85 θ19 × -35 θ18 RCL5 36 85 θ19 × -35 θ18 RCL5 36 85 θ19 × -35 θ19 × -35 θ20 RCL6 36 86 θ21 + -24 θ22 RCL6 36 86 θ22 RCL6 36 86 θ22 RCL5 36 85 θ22 RCL5 36 85 θ22 RCL5 36 85 θ23 RCL5 35 85 θ24 8705 870 θ25 6 96 θ27 × -35 θ28 RTN 24 θ29 ST01 35 87 θ26 RCL5 36 85 θ27 × -35 θ28 RTN 24 θ29 ST03 35 83 θ26 RCL5 36 85 θ27 × θ28 RCL5						069	l X			
e15 × -35 e71 <i>R</i> CL5 36 66 e16 <i>R</i> CL4 36 e83 × -35 e73 × -35 e19 <i>x</i> -35 e73 <i>x</i> -35 e75 <i>R</i> CL6 36 e6 e11 <i>R</i> CL7 36 e7 <i>x</i> -35 e75 <i>R</i> CL6 36 e6 e20 <i>R</i> CL7 36 e6 e77 <i>x</i> 53 e75 e7 e7 e7 53 e75 e7 e7 e7 sa e7 e7 e7 sa e7 e7 sa e7 e7<								36 01		
θ17 x -35 θ73 x -35 θ18 RCL5 36 95 973 x -35 θ19 x -35 975 RCL6 36 96 θ20 RCL7 36 97 975 RCL6 36 96 θ21 ± -24 977 X 53 975 RCL6 36 96 θ22 TX 54 975 876 ± -24 975 876 ± -24 θ23 RCL6 36 86 879 5107 75 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 87 86 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99									1	
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θ25 6 θ6 θ25 6 θ6 θ26 RCL5 36 θ27 × -35 θ28 - -45 θ29 ST01 35 θ28 RTN 24 θ31 #LELE 21 θ32 RTN 24 θ33 R1 -31 θ34 ST05 35 θ5 RCL2 21 θ33 R1 -31 θ4 6 060 93 #LELD 21 θ4 6 060 θ44 6 06 θ44 6 06 θ44 6 06 θ45 -24 θ46 4 θ47 RCL5 36 θ48 ÷ θ49 X² θ59 RCL3 θ59 RCL3 θ58 RCL3 θ25 × θ45 -24 θ49 X² θ58 RCL3 θ58 RCL3 θ58 RCL3 θ58 RCL3 θ59 -24 θ45										
626 RCL5 36 65 927 x -35 928 - -45 929 ST01 35 91 930 RTN 24 931 xLBLB 21 2 932 ST02 35 95 933 RV -31 934 ST05 35 95 935 RTN 24 937 ST03 35 93 938 RUL 21 14 944 64 64 -35 944 6 96						<u>⊢−−−</u> †		+		
θ27 x -35 θ28 - -45 θ29 ST01 35 θ29 ST01 35 θ29 ST01 35 θ29 ST01 35 θ30 RTN 24 θ31 #LBLE 21 θ32 ST02 35 θ28 ST02 35 θ34 ST05 35 θ37 ST03 35 θ37 ST03 35 θ39 +LBLD 21 θ40 ST04 35 θ42 RCL1 36 θ43 RCL1 36 θ44 6 06 θ45 -24 θ44 6 θ45 -24 θ44 6 θ45 -24 θ49 X2 950 RCL2 950 RCL2 965 RCL3 965 CL7 965 4 975 S1 985 4 950 RCL3 950 RCL7 96 100 97 AT 9 10 <td></td> <td></td> <td></td> <td></td> <td></td> <td> </td> <td></td> <td></td> <td>-</td> <td></td>									-	
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θ29 ST01 35 θ1 θ30 RTN 24 θ31 RLBLE 21 12 θ32 ST02 35 θ2 θ33 R4 -31 θ34 ST05 35 θ5 θ35 RTN 24 θ36 *LBLC 21 13 θ37 ST03 35 θ3 θ36 *LBLC 21 13 θ37 ST03 35 θ3 θ38 RTN 24 θ39 *LBLD 21 14 θ40 ST04 35 θ4 θ41 R/S 51 θ42 RCL1 36 θ1 θ43 RCL5 36 θ5 θ44 6 θ6 θ45 × -35 θ44 4 6 θ6 θ45 × -35 θ44 4 6 θ6 θ45 × -35 θ46 4 -55 θ47 RCL6 36 θ6 θ48 ± -24 θ49 X2 53 θ50 RCL2 36 θ5 θ51 RCL5 36 θ5 θ52 × -35 θ53 RCL7 36 θ7 θ56 ± -24 θ56 ± -24 θ56 ± -24 θ56 ± -24 θ56 ± -24 θ56 ± -24 θ51 RCL7 36 θ7 θ57 RCL7 36 θ7 θ56 ± -24 θ56 ± -24								<u> </u>	-	
030 RTN 24 031 *LBLE 21 032 ST02 35 033 RJ -31 034 ST05 35 035 RTN 24 036 RLBLC 21 037 ST03 35 038 RIN 24 037 ST03 35 038 RIN 24 039 *LBLD 21 041 R/S 51 042 RCL1 36 044 6 06 043 RCL2 36 044 6 06 045 × -35 046 + -55 047 RCL6 36 048 + -24 049 ½ 2 050 RCL2 36 051 RCL3 36 052 × -35 053 RCL3 36 054 × -35 055 RCL3 36 055 RCL3 36 055 RCL3 36 055 RCL3 65 055 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td>┣───┤</td> <td></td> <td></td> <td>-</td> <td></td>						┣───┤			-	
031 ±LELE 21 12 032 STO2 35 02 033 R4 -31 034 STO5 35 05 035 RTN 24 036 RIBLC 21 037 STO3 35 03 038 RIBLD 21 14 040 STO4 35 04 041 R/S 51 042 RCL1 36 043 RCL5 36 044 6 06 045 × -35 046 + -55 047 RCL6 36 048 ÷ -24 049 ½ 53 050 RCL2 36 045 x -35 051 RCL5 36 052 × -35 053 RCL7 36 07 054 × -35 055 RCL7 36 07 056 ÷ -24 100 10 08 045 × -35 055 RCL7 36 051									-	
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θ33 RJ -31 θ34 ST05 35 θ35 RTN 24 θ36 #LBLC 21 θ37 ST03 35 θ38 RTN 24 θ37 ST03 35 θ38 RTN 24 θ37 ST03 35 θ38 RTN 24 θ39 #LBLD 21 θ41 R/S 51 θ42 RCL1 36 θ44 6 06 045 X -35 θ46 + -55 θ47 RCL2 36 θ48 ÷ -24 θ49 X² 53 θ50 RCL2 36 θ51 RCL2 36 θ52 × -35 θ53 RCL3 36 θ53 RCL7 36 θ7 * -24 θ54 × -35 θ55 RCL7 36 θ7 * -24 θ56 ÷ -24 θ56 ÷ -24 θ56 ÷ -24 θ5 <						<u> </u>			-	
θ35 RTN 24 θ36 #LBLC 21 13 θ37 ST03 35 93 θ38 RTN 24 θ39 #LBLD 21 14 θ40 ST04 35 64 θ41 R/S 51 Calculate M θ42 RCL1 36 01 θ43 RCL5 36 05 θ44 6 06 045 × -35 046 + -55 047 RCL6 36 06 048 ÷ -24 049 ½ 2 53 050 RCL2 36 05 Est Status 051 RCL3 36 03 08 Sci Begisters 0 100 0 08 Sci Begisters 0 100 1 08 Sci Begisters 0 100 1 08 9 Sci Begisters Sci Begisters <	033								-	
θ36 *LBLC 21 13 θ37 \$103 35 83 θ38 RTN 24 θ39 *LBLD 21 14 θ40 \$104 35 84 θ41 R/S 51 θ42 RCL1 36 85 θ44 6 96 θ43 RCL5 36 85 θ44 6 96 θ45 × -35 θ46 + -55 θ47 RCL6 36 86 θ48 ÷ -24 θ49 ½ 53 θ50 RCL2 36 82 θ51 RCL5 36 85 θ52 × -35 θ53 RCL3 36 83 θ54 × -35 θ55 RCL7 36 87 θ56 ÷ -24 HEGISTERS 8			35 05			090		1	-	
037 ST03 35 03 028 RTN 24 039 *LBLD 21 14 040 ST04 35 04 041 R/S 51 Calculate M										
038 RTN 24 033 *LBLD 21 14 040 \$T04 35 04 041 R/S 51 Calculate M										
639 *LBLD 21 14 040 ST04 35 04 041 R/S 51 042 RCL1 36 05 043 RCL5 36 05 044 6 06 045 × -35 046 + -55 047 RCL6 36 06 048 ÷ -24 049 X² 53 050 RCL2 36 05 051 RCL3 36 05 052 × -35 053 RCL3 36 07 0555 RCL7 36 07 056 ÷ -24 0 1 Ins. 2 hrs/yr 3 1 Ins. 2 hrs/yr 3 53 54 51 S2 S3 51 S2 S3 51 S2 S3										1
040 ST04 35 04 041 R/S 51 042 RCL1 36 01 043 RCL5 36 05 044 6 06 045 x -35 046 + -55 047 RCL6 36 048 ÷ -24 049 x² 53 050 RCL2 36 051 RCL3 36 052 x -35 053 RCL3 36 054 x -35 055 RCL7 36 056 ÷ -24 0 1 10 100 10 100 10 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 1 110 <td></td>										
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042 RCL1 36 01 0410 Hate M										
043 RCL5 36 05 044 6 06 045 x -35 046 + -55 047 RCL6 36 048 ÷ -24 049 ½² 53 050 RCL2 36 051 RCL3 36 052 X -35 053 RCL3 36 054 X -35 055 RCL7 36 054 X -35 055 RCL7 36 054 X -35 055 RCL7 36 045 ÷ -24 056 ÷ -24 REGISTERS 0 1 Ins. 2 hrs/yr 3 ΔT 4 M 5 k 6 Const 7 b 8 9 1 Ins. 2 hrs/yr 3 ΔT 4 M 5 <t< td=""><td></td><td></td><td></td><td>Calculate I</td><td>Μ</td><td></td><td></td><td></td><td>4</td><td></td></t<>				Calculate I	Μ				4	
044 6 06 045 × -35 046 + -55 047 RCL6 36 048 ÷ -24 049 X² 53 050 RCL2 36 051 RCL3 36 052 X -35 053 RCL3 36 054 X -35 055 RCL7 36 056 ÷ -24 REGISTERS 0 1 Ins. 2 hrs/yr 3 ΔT 4 M 5 k 6 Const 7 b 8 9 S0 S1 S2 S3 S4 S5 S6 S7 S8 S9									4	
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A B C D E I	S0	S1	S2	Ŝ3	S4	S5	S6	S7	S8 S9)
									<u>_</u>	
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Program Title	Heat Transfer Throu	gh Composite Cylinders and	Walls
Contributor's N	ame Hewlett-Packar 1000 N.E. Circl	· · · · · · · · · · · · · · · · · · ·	
City	Corvallis	State Oregon	Zip Code 97330
rogram Descr	iption, Equations, Variables		· · · · · · · · · · · · · · · · · · ·
	cient for comp	can be used to calculate the overall heat t posite tubes and walls from individual se face coefficients.	
		T ₁	

Operating Limits and Warnings These equations are for steady state heat transfer through materials with constant properties in all directions. Inputs must start with the inside convective coefficient and work out in the case of composite cylinders.

Figure 2. -Composite wall

Zero is an invalid input for D, k, and h.

Figure 1.-Composite tube

Dimensional consistency must be maintained.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Title Heat	t Transfer Through Comp	osite Cylinders and Wa	alls
Contributor's Name	Hewlett-Packard		
Address	1000 N.E. Circle Blvd.		ан — анг. Тагаагааса на на мала мала мала мала на тур улу улуу улуу жага су тур улуу жага су тур улуу жага жага
City Corva	allis	State Oregon	Zip Code 97330
Program Description, E	Equations, Variables		
, ,	The overall heat transfer coe	fficient U is defined by:	
ninniniin i ina sast		$q/L = U \Delta T$	a da serena
an an an an ann an an an an an an an an		-	······································
		or	11 11/10 1 1 00 10 10 10 10 10 10 10 10 10 10
<u></u>		$q/A = U \Delta T$	
	where ΔT is the total temp	perature difference (T ₂ – T ₁), q	/L is the
	• –	of pipe, and q/A is the heat tra	nsfer per
	unit area of wall.		
	For cylinders		
tat erranna ar	II =	2π	
	$\frac{2}{\frac{1}{1-\frac{1}{2}}} + \frac{\ln D_2}{\frac{1}{1-\frac{1}{2}}}$	$\frac{2\pi}{\frac{D_1}{D_1} + \frac{\ln D_3/D_2}{k_2} + \ldots + \frac{2}{h_n D_n}}$	
tha thao i i i i i a i i i	h_1D_1 k_1	$k_2 hinspace h_n D_n$	
	For walls		
1998 A.L		1	
	U =	$\frac{1}{\frac{x_1}{x_1} + \frac{x_2}{k_2} + \dots + \frac{1}{h_n}}$	
a manana an isan a s	$\frac{1}{h_1} + \frac{1}{k}$	$\frac{1}{k_1} + \frac{1}{k_2} + \dots + \frac{1}{h_n}$	
er vel vel a vel en e velen e i vel val e i vel vel	where		
	h is the convective s	urface coefficient:	
	D_n is the outside diam		
16. A	k is the conductive of		
	x is the thickness of		······
		· · · · · · · · · · · · · · · · · · ·	
			NU DESENT AND

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Sketch(es)			······································
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Sample Problem(s)			
oumpto : : extension (-)	Example 1:	anna a na fairtean ann an	
	A steel pipe with an inside dian	neter of 4 inches and a thickness of	
	0.5 inches has a conductivity exhaustion $(k = 0.1 \text{ Btu/hr-ft-}^\circ \text{F})$	of 25 Btu/ft-hr-°F. Two inches of enclose the pipe bringing the total	
א יישאר או איז אין איז	diameter to 9 inches. If the in	nside convective coefficient is 1000	
	Btu/hr-ft ² -°F and the outside co	oefficient is 5 Btu/hr-ft ² -°F, what is	
and the a community of a cancel and the second s	the overall heat transfer coeffic feet of pipe if ΔT is 115°F?	cient? What is the heat loss for 100	
	-		10 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1
والمتراجع والمتراجع	Keystrokes	See Displayed	
	4 🕂 12 🕂 1000 🗛 5 🕂 12 🕂 :		
	0.1 B 9 ♠ 12 ÷ 5 A C	► 0.98 Btu/hr-ft- [°] F	
		→ 112.44	
	115 🗙 ———————	Btu/hr-ft	
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	100 🗵	→ 11244.20	
		Btu/hr	
	Example 2:		
Solution(s)		of brick ($k = 0.4$ Btu/hr-ft-°F), and 1	
	inch of wood (k = 0.12 Btu/hr-	ft-°F). The convective coefficient on	
	one side is 23 Btu/hr-ft ² -°F. The	he convective coefficient of the other s the overall coefficient? What is the	
	heat flux if the temperature diff	ference is 70°F?	
MT403.547995400 1.156-17.15.19.17.4.19.00			1
	Keystrokes	See Displayed	11.1 × 11.100 × 11.
appending and appendix and a state of the st	RTN 1 🕂 0.4 E 1 🕂 12 🕂 .12	2 E 23 D 5 D C ► 0.29 Btu/ft ² -hr-°F	· · · - · ·
		► 20.36	
	70 🗙 —————	Btu/ft ² ·hr	
••••••••••••••••••••••••••••••••••••••			
Reference (s)			

User Instructions

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COMPOSITE	CYLIND	ERS AND WA	us	
RTN=START	Dŧk	÷U	h	X ‡ k

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	For a composite wall go to			
	step 9.			
3	Input the inner diameter	D _{in}		D _{in}
4	Input the inner convective			
	coefficient	h _{in}	A	2/hD
5	Input next diameter value	D		D
	and corresponding coefficient	k or h	В	
6	Go to step 5 for next surface			
	or go to step 3 for outside			
	surface*			
7	Calculate overall heat transfer			
	coefficient		С	υ
8	To calculate another overall			
	coefficient, go to step 2			
9	Input the coefficients for each			
	section of the wall:			
	Convective coefficient	h	D	1 <i>/</i> h
	or length of conductive path	x		
	and conductive coefficient	k	E	x/k
10	Go to step 9 for next input*			
11	Calculate overall heat transfer			
	coefficient		с	U
12	To calculate another overall			
	coefficient, go to step 2			

* Press RTN to restart a calculation.

ΈP			97 Program				~~~~	AENTO
	KEY ENTRY		COMMENTS	STEP	KEY ENTRY	KEY CODE	COM	MENTS
001	*LBLA	21 11	Initialize					
002 003	Pi ST06	16-24 35 06	Initialize					
003 004	CLX	-51		060				
005	STOS	35 08						
806	R↓	-31						
887	X≠Y	-41						
008	ST07	35 0 7						
809	X≢Y	-41						
010	GTOA	22 11	Idle					
011	*LBL1	21 01	Tule					
012	RTN	24						
013	≭LBL A	21 11		070				
014 015	× 1/X	-35 52	Add convective					
015 016		35-55 08	factor					
017	RTN	24	i					
018	*LBLB	21 12						
019	1/X	52						
020	XZY	-41						
021	RCL7	36 07						
022	X≢Y	-41	Add conductive					
823	ST07	35 07	factor	080				
824	÷	-24	1 de toi	000				
025	LN	32						
026 027		-35 02						
027 028	2 ÷	-24						
020		35-45 08						
020	GT01	22 01						
031	*LBLC	21 13	Calculate U					
032	RCL8	36 08						
833		52						
834	RCL6	36 06		090				
035		-35						
<i>036</i>		35 04						
837		24	Add convective					
038		21 14	factors				· · ·	
039 040		01 -41			· ····································			
041	*LBLE	21 15						
842		01						
043		35 ØE				1	1	
044	CLX	-51		100]	
845	STO8	35 0 8						
846		-31						
847		22 15						
048		21 02			ELACO	L	SET STATUS	
049 050		24 21 15			FLAGS			
050 051	≭LBLE X≢Y	-41	Add conductive		H <u> </u>	FLAGS	TRIG	DISP
051 052		-41 -24	factors		∔ - 1		DEG 🛛	FIX X
853		21 14	ructors	}	2		GRAD 🗆	sci 🗆
054		52		110	<u>-</u>	- 2 🗆 😡	RAD 🗆	ENG n_2_
055	ST+8	35-55 08				3 🗆 🙀		
05 6	GT02	22 02						
				GISTERS		7	8	19
	1	2	3 ⁴ U	5	⁶ lor	π Used	ΣR	
	S1	S2	S3 S4	S5	S6	S7	S8	S9
							<u> </u>	
		В	C	D		E	1	

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Program TitleSteady State Conductive Heat Transfer, Heat Load and Logarithmic
Mean Temperature DifferenceContributor's NameHewlett-PackardAddress1000 N.E. Circle Blvd.CityCorvallisState OregonZip Code97330

Program Description, Equations, Variables Given any Three variables $(Q,U, A\&\Delta t_m)$ OR $(Q,W,C_p\&\Delta t)$ The Program Computes the Fourth Variables: $Q = UA\Delta t_m$, $U = \frac{Q}{A\Delta t_m}$, etc. $Q = WCp\Delta t$, $C_p = \frac{Q}{W\Delta t}$, etc Given Temperature Conditions

 $(T_1, T_2, t_1 \& t_2), (t_1 \& t_2) \text{ or } (T_1 \& T_2)$

The Program Computes:

 $\mathbf{OR} \quad \Delta \mathbf{t}_{\mathrm{m}} = \frac{\Delta_2 - \Delta_1}{\ln(\Delta_2/\Lambda)}$

$$\Delta t = (t_2 - t_1), (T_2 - T_1).$$

To combine these three basic heat transfer equations will increase the flexibility and speed of heat transfer design.

Operating Limits and Warnings

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Reference(s) McAdams, W.H., Heat Transmission, McGraw-Hill Book Co.

This program is a translation of the HP-65 Users' Library program #00648A submitted by Yu Tsung Pei.

User Instructions

Steady State Conductive Heat Transfer, Heat Load and Log Mean Temperature Difference **4**1

7 Q \triangle or C_{D} $\triangle t_{m}$ or $\triangle t$ $\triangle t_{m}$ or $\triangle t$ U or W

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
١.	Load program			
2.	Compute Q			
	Input U Btu/(hr)(°F)(sw ft) or W lb/hr Input A sq ft or C _p Btu/(lb)(°F)	UorW		UorW
	Input A sq ft or C Btu/(Ib)(°F)	A or C _p		A or C _p
	Input Δt °F or Δt °F	∆t _m or∆t		Ator∆t
2.	Compute U or W			
	Input Q Btu/hr	А	[A] [_]	Q
	Input A sq ft or C _n Btu/(1b)(°F)	A or C _p		A or Cp
	Input A sq ft or C_Btu/(1b)(°F) Input ∆t_°F or ∆t °F	∆T _m or∆t		∆t _m or∆t'
2.	Compute A on C			U.or W
2.	Compute A or C _p	Q		Q
	Input Q Btu/hr Input U Btu/(hr)(°F)(sq ft) or W 1b/hr	U or W	[. B .][]	U or W
	Input ∆t _m °F or ∆t °F	\\ \t_mor \\ t	[D] [] [∆t _m or ∆t
			0 C	A or C _p
<u> </u>				
2.	Compute t or t	Q		0
	Input Q Btu/hr Input U Btu/(hr)(°F)(sq ft) or W lb/hr	U or W		U or W
				A or C _p
	Input A sq ft or C Btu/(lb)(°F)	A or C p		∆t _m or ∆t
3.	$\begin{array}{c} \text{Compute } \wedge t_{m} \text{ or } \wedge t \text{ from } T_{1}, T_{2}, t_{1} \& t_{2}. \\ \hline T_{1} & T_{2} \\ \hline \end{array}$			
	1 1 1 1 1 1 1 1 1 1	T		
	t ₂ t ₁	t_2 T_2 or t_2		
		6 6	<u>↑</u> []	T ₂ of t ₂
		t _l or t _l		At or At
<u> </u>				
	· · · · · · · · · · · · · · · · · · ·			
[

Program Listing I

26			77 i lugiam			L		
STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMM	IENTS
001	*LBLA	21 11		057	*LBL0	21 00		
882	8	00	Compute the Q	858	-	-45		
883	S≢Y	-41		Ø59	RŤ	16-31	T + - A	
884	X≠Y?	16-32		060	X=Y?	16-33	$T_{1} - t_{2} = \Delta_{2}$ $T_{2} - t_{1} = \Delta_{1}$ $\Delta_{2} = \Delta_{1} =$	2
005	GTC1	22 01		0E1	R∕S	51		
006	RCL2	36 02		062	X£Y?	16-35	'2 ^{-ℓ}] ⁼ ∆1	
007	RCL3	36 03		863	X≢Y	-41		
008	RCL4	36 04		864	ST05	35 05	$\Delta_2 = \Delta_1 =$	Δt _m
889		-35		065	STOE	35 06		
010		-35		066	R↓	-31		
011	STC:	35 01		867	ST-5	35-45 05		
012	RTN	24	1	868		35-24 06		
013	*LBLE	21 12		069	RCL5	36 05		
014	8	00	Compute the U or W	676	RCLE	36 06		
815	X₽Ÿ	-41		871	LN	32		
815 816	∴+. X≠Y?	16-32		872	÷	-24		
				073	ST04	35 04		
817		22 02 75 01	1	073 074	RTN	30 04 24		
618 819	RCL1 RCL7	36 01 76 07		074 075				
819		36 03 76 04			*LBL1	21 01		
820	RCL4	36 04	1	876 877	ST01	35 01		
021	Х	-35		077 070	R/S	51		
<i>022</i>	÷	-24	1	078 078	*LBL2	21 02 75 02		
023		35 02	1	079 800	STO2	35 02		
824	RTN	24	1	080	R∕S	51		
025	*LBLC	21 13	Compute the A or C	081	*LBL3	21 03		
826		0 0		882	ST03	35 03		ŕ
027		-41		083	R∕S	51		
028		16-32		084	*LBL4	21 04		
829		22 03		085	ST04	35 04		
030	RCL1	3E 01		086	R∕S	51		
031	RCL2	36 02						
032	RCL4	36 04	1			1	[
833	x	-35					1	
834	÷	-24	1	090]	
835	STO3	35 03					1	
036		24		î			1	
837		21 14					1	
038		88	Compute Δt_m or Δt				1	
839		-41					1	
848		16-32					1	
041	GT04	22 04	1	┣────┼	<u> </u>	- <u> </u>	1	
042		36 01	ł	┝──┼			1	
843		36 82	1	┠────┼			1	
844		36 03		100			1	
845		-35	4				1	
045 046		-24	1	┝────┾			4	
040 847		35 04	1	┣∔			4	
047 048		24	1	ļ			4	ŀ
643 849		21 15	1		<u> </u>		ł	}
		-45	Compute Δt_m or Δt				L	
050 051				┝───┤		 _ 	SET STATUS	
051 052		-31	from T_1, T_2, t_1 or t_2			FLAGS	TRIG	DISP
852 857		16-32				ON OFF		
053 054		22 00	l				DEG 🛛	
054 055		16-31		110				
855		35 04	1	$ \downarrow \downarrow$	·	$\begin{array}{c c} 2 & \Box & \overleftarrow{\mathbf{x}} \\ 3 & \Box & \overleftarrow{\mathbf{x}} \end{array}$	RAD 🗆	ENG D
056	RTN	. 24	L			3 🗆 😥		····
			REGIS	STERS			10	10
0	1 Q	² U,W	3 A,C _p 4 Δt_{m} , Δt	⁵ Δ ₁	⁶ Δ ₂	7	8	9
								S9
S0	S1	S2	S3 S4	S5	S6	S7	30	39
								L
Α		В	с	D		E	I	

Program Title	Sun Altitude, Az	imuth, Sola	ar Pond	Absorpti	on			
				·				
Contributor's	Name Hewlett-Packa	^d						
Address	1000 N.E. Circle	31vd.						
City	Corvallis		State	Oregon		Zip Code	97330	
							· · · · · ·	
Program Des	cription, Equations, Variables							
Given:		•					ter	
spring	g equinox, and number of	of hours be	fore of	r after s	olar noc	on;		
	rogram_computes: <u>the</u>							
h =	= sin ⁻¹ (cos 1 cos d cos	s t + sin 1	sin d)				
	1 - latitude in	decimal de	grees					
	d = sun's decli					d . .		
	D = (no. of	days after	sprin	g equinox)(0.9856	; <u>degrees</u>) day		
	t = (no. of hour	rs before o	or afte	r solar n	oon);	Ū		
	the sun's azimu	th A.						
Α =	the sun's azimu cos ⁻¹ (cos i sin 1 cos 1 s	sind)						
	cos 1 s	sini '						
	i = 90 - h;							
	the fraction	n of solar	radiat	ion strik	ing the	pond surf	ace	
	<u>which will</u>	penetrate t	he pon	d surface	<u>, Е,</u>			
Fra	action E = $2n(a^2 + b^2)$	cos i cos	r					
	$a = \frac{1}{\cos r + n\cos^2 r}$	where	r - si	$n^{-1}(\frac{\sin i}{2})$.)			
	1			· n				A
	$b = \frac{1}{\cos i + n\cos i}$	r						
	n = index of ref	raction of	pond 1	fluid				
(refs:	Smithsonian Physical	Tables, 9t	h rev.	Ed. & We	inberger	, H., Sol	ar ener	<mark>gy,v</mark> 8
	1954 (p 729)				1964 (pp			
				· · · · ·				
OPERATING	LIMITS AND WARNINGS					·····		
Does n	ot compute azimuth at	latitude o	f 90 de	grees.				
this program	has been verified only with respec material AT HIS OWN RISK, in reli resentation or description concerni	ance solely upor	n his own					
PROGRAM M FOR A PART	NOR THE CONTRIBUTOR MAKES ATERIAL, INCLUDING, BUT NOT L ICULAR PURPOSE. NEITHER HP N ES IN CONNECTION WITH OR AR	IMITED TO, THE	E IMPLIED RIBUTOR S	WARRANTIE	S OF MERO	CHANTABILITY	' AND FITI R CONSEQ	NESS UEN-

Sketch(es)	
Low C.	e en e e e i e a e a a a a a a a a a a a a a
Loc.	
41 7 ("	
Sample Problem(s)	
Find the sun's altitude, azimuth, and the fraction of the	
penetrate the surface of a solar pond under the following	
Index of refraction of pond fluid n = 1.33	an a
Latitude 1 = 46.00	
Days after spring equinox = 68	
Hours before solar noon = 4	
	· · · · · · · · · · · · · · · · · · ·
Solution(s)	
h = 35.99 degrees	
A = 84.41 degrees	
E = 0.96	
Keystrokes:	Outputs:
23.45[ST0][1] .9856[ST0][2] 1.33[ST0][3]	
46[A] 68[B] 4[C]>	35.99
[R/S]>	84.41
[R/S]>	0.96
Reference (s)	
Smithsonian Physical Tables, 9th rev. Ed., 1954, (p 729)	

Weinberger, H., Solar Energy, vol 8, no. 2, 1964 (pp 45-56) This program is a translation of the HP-65 Users' Library program #00683A submitted by Robert J. Zaworski.

User Instructions

Sun Altitude, Azimuth, Solar Pond Absorption

DAYS

6

LAT

_	HRS	-	•	

	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Enter program			
2.	Introduce constants	23.45	STO 1	
		0.9856		
		n		
		· · · · · · · · · · · · · · · · · · ·		
3.	Input latitude (0 to 90) in decimal degrees	latitude		
	Input numbers f days (0 to 200) after Causing			d
4.	Input numberof days (0 to 365) after Spring	days		
	Fquinox			
5	Input number of hours (0 to 12) before or			h
	after solar noon, and compute altitude			
	ur cer sorar noon, and compare artriade			
6.	Compute azimuth		[R/S] []	A
	•			
7.	Compute the fraction of solar rediation			E
 	striking the pond surface which will penetrate			
	the pond surface			
		i		
\vdash				
$\left - \right $				
$\left \right $				

97 Program Listing I

30			77 Program	Insung I		
CTED	VEV ENTRY	KEY CODE	COMMENTS	STEP KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	[057 GSBE	23 15	
002	COS	42		058 RCL6	36 06	
603	STO4	35 04	loop 1 in 4	059 RCL7	36 07	
004	LSTX	16-63	cos 1 in 4	060 RCL3	36 03	
005	RTN	24				
			stops with latitude	061 GSBE	23 15	
006	*LBLB	21 12	in x	06 2 +	-55	
007	RCL2	36 02		063 RCL3	36 03	
008	X	-35		064 X	-35	
009	SIN	41		065 2	02	
010	RCL1	36 01		066 ×	-35	
011	Х	-35		067 RCL6	36 06	
012	ST05	35 05	d in 5	068 X	-35	
013		24		069 RCL7	36 07	
014		21 13	stops with decl.in x	070 ×	-35	
615		01		071 RTN	24	
015		05		072 *LBLD	21 14	
		-35				
617			1	073 COS-'	16 42	
018		42 75 aa		074 SIN	41	
019		35 08		075 RTN	24	· · ·
020		3E 04		076 *LBLE	21 15	
B 21		-35	1	077 X	-35	
022	RCL5	36 0 5	1	078 +	-55	
023		42		079 ENT†	-21	
024		-35		080 ×	-35	
025		36 04		081 1/X	52	
026		23 14		082 RTN	24	
020 027		36 05				
		36 8 3 4 1		083 R/S	51	
028					<u> </u>	
029		35 07				
030		-35				
031		-55				
032	STD€	35 Ø6				1 1
033	SIN-	16 41	Stops with alt. in x			
034	R/S	51		090		
035		36 06				1 1
036		36 04				
037 037		23 14				
037		-35				1
. 039		36 0 7				
640		-45				
041		36 04				j i
642		-24	·		1]
043		36 06			1	1 I
044		23-14		100	+	1
645	5 ÷	-24			<u>+</u>	1 1
646		16 42			<u> </u>	1 1
647		51	Stops with azimuth		+	4
048		36 06	in x			4 1
040		23 14			<u>↓. </u>	4 1
045 050		23 14 36 03				
		36 03 -24				SET STATUS
051 052					FLAGS	TRIG DISP
052		16 41			ON OFF	
053		42				DEG 🖾 🛛 FIX 🙀
654		35 07	cos r in 7	110		GRAD 🗆 🛛 SCI 🗆
055		36 06			2 0 00	RAD 🗆 ENG 🗆
. 056	5 RCL3	36 03	1			n_ <u>2</u>
		<u></u>	PEOL	STERS		
<u> </u>			c 2 n (index)4		. 7	8 9
0	23.4	20.9856	of notices 1	declination cos	i sin d/co	sr cos t
			of refrac	S5 S6	S7	S8 S9
S0	S1	S2	53 54			
				D	TE	
А		в	С		L.	T I
1		1			1	

Contributor's Name Hewlett-Packard Address 1000 N.E. Circle Blvd.	
Contributor's Name HEWIELL-PACKARD	

Program Description, Equations, Variables This program determines the total amount of solar radiation received by a horizonatal surface of unit area during one calendar day. The result is expressed as equivalent hours of direct sunshine if sun were stationary and directly overhead. Also computes length of daylight and accumulates total radiation in R7 for succesive calculations. Input variables are latitude, L, suns declineation (from nautical almanac) in decimal degrees.

Day Length = 24 θ/π , θ expressed in radians

 θ = Arc cos (-sin L Sin D/cos L cos D)

Total Radiation = $2\int_{0}^{\theta} \sin H d\theta$

= $(\sin L \sin D) \theta$ + $\cos L \cos D \sin \theta$

Operating Limits and Warnings

North latitudes and declinations are entered as positive values south as negative values.

The value 90-L+D must be greater than zero.

Equations assume surface level with horizon and ignores atmospheric refraction and

assume cloudless sky.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Sample (1) 1.00 Area = 7.63944 12 hrs 6:00am 9:00am 12:00 3:00pr	0.6366 n	
Sample Problem(s) (1) Equator, March 21 L = 0, D = 0		
(2) North Pole, June 21, L = 90°, D = +23.45°		
<pre>(3) Cupertino, CA 95014, September 15, 1974 L = 37.32°, Dec = +2.93°</pre>		
Solution(s)		
(1) DHY length = 12.00 hrs Total Rad = 7.6394	hrs	
(2) " = 24.00 " " = 9.5508		
(3) " " = 12 hrs, 17 min, 53 sec. Total R	ad = 6.4439	
Keystrokes:	Outputs:	
(1) O[E] O[A] O[B] [C]	12.0000 7.6394	
(2) 0[E] 90[A] 23.45[B] [C]	24.0000	
(3) 0[E] 37.32[A] 2.93[B]	9.5508 12.1753	
	6.4439	
 Reference(s) (1) The Nautical Alamanac, U.S. Naval Observatory Documents, Washington D.C., 20402. (2) American Practical Navigation, Bowditch U.S. Also chapter XIV. (3) Britannica Atlas This program is a translation of the HP-65 Use Submitted by Robert B. Egbert. 	Naval Oceanographic Office, pg 531,	
	Total Daily Solar Rad	7
-----	-----------------------------------------------------------------	---
LAT	DEC $\int_0^{\theta} \sin H d\theta = R - 7 = 0 \rightarrow R7$	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Read Card			
2.	0 → R7	0.00	E	0.00
3.	Input latitude °N +	LAT °N		LAT (+)
	or °S -	LAT °S	CHS A	" (-)
4.	Input suns declination °N +	DEC °N	B	HOURS
	or <u>°S</u>	DEC °S	CHS B	DAYLIGHT
5.	or $^{\circ}S =$ Compute total rad = $2\int_{0}^{\theta} \sin H d\theta$			TOTAL RAD
				HRS
	To obtain total radiation for a number of days			
	n (up to May of 365), repeat steps and 5.			
				-N-o-
6.	Total radiation for N days			Σ^{N} TOT RAD
	TABLE OF SUNS DECLINEATION (DECIMAL DEGREES)			
	DATE DEC DATE DEC DATE DEC			·
	Jan 1 -23.00 May 7 16.85 Sep 3 7.30 8 -22.38 14 18.67 10 4.88			
	15 -21.08 21 20.22 17 +2.20			
	<u>22 -19.63</u> 28 <u>-21.48</u> <u>24 -0.50</u>			
	<u>29 -17.88 June4</u> <u>22.45 Oct 1 -3.24</u> Feb 5 -15.87 11 23.10 8 -5.94			
	12 -13.63 18 23.42 15 -8.57			
	<u></u>			
	<u>26 - 8.75 July2 23.05 29 -13.50</u> Mar 5 - 6.00 9 22.35 Nov 5 -15.72			
	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			
	19 - 0.50 23 - 20:05 - 19 - 19:50			
	<u>26 + 2.27</u> 30 18.48 <u>26 -20.97</u> Apr 5 5.00 Aug 6 16.66 Dec 3 -22.09			
	9 7.63 13 14.63 10 -22.93			
	16 10.17 20 12.40 17 -23.36			
	<u>23 12.58 27 10.00 24 -23.42</u> 30 14.82 31 -23.09			
 	<u> </u>	<u>}</u>		
	· · · · · · · · · · · · · · · · · · ·	<u> </u>		
 		+		
		1		

÷

34			// i i vgi am			
STEP	KEY ENJRY	KEY CODE	COMMENTS	STEP KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11		057 ENTT	-21	
002		-63 04	Enter latitude &	058 RCL7	36 07	
003		35 01	store in R-1	059 +	-55	
004		51	4	060 ST07	35 07	
005		21 12		061 R4	-31	
006		35 02	Enter sums dec-	062 R/S	51	Display sums
007		16-21	lination and compute	063 *LBLD	21 14	accumulated in R-7
008		36 01	no. of hours of	064 KUL7	36 0 7	
009		41	sunshine	065 R/S	51	
010		36 02	suisinne	066 *LBLE	21 15	Stores zero in R-7
010		36 62 41		067 0	00	for new series of
012		-35		068 ST07	35 07	
			1	069 R/S	51	calculations
013		35 03		070 *LBL1	21 01	Limits of integra-
014		36 01		071 2	02	tion for midnight
015		42		672 4	04	s or case
016		36 02		073 ST05	35 85	
017		42		074 R/S	51	
018		-35	1		01	
019		35 04	This take			
020		16-35	This takes care of		+	┥ │
021		22 01	midnight sun		<u> </u>	4
022		36 03	4	┝───┼─────		4
023	RCL4	36 04 -		000	ļ	4
024	÷	-24		080		
025	CHS	-22				4
026		16 42				
027		07				
028		-62	Converts degrees			
629		05	(θ) to length of]
030		-24	day in hr, min,sec			1 I I I I I I I I I I I I I I I I I I I
031		35 05	1			
032		16 35	1			1
032		51	1			1
034		21 13		090		1
035		36 05	θ is converted to			
035 036		16-24	radians to perform			1
			the integration &			1
Ø37 979		-35	result is converted			4
038		02	to hours		1	1
039		Ø4 -				-
040		-24 . 75 oc		<u>├</u>		4 1
041		35 06		┣─── ┤ ────	······	4 1
042		16-22			+	4
043		36 03	4	100	<u> </u>	4 1
044		36 06			<u> </u>	4 1
045		-35			· · · · · · · · · · · · · · · · · · ·	4 . I
046		36 04 .				4
047		36 06 .		┝──		4 1 1
048		41			_	4 1
049		-35 .		L	<u></u>	
050	÷	-55			↓	SET STATUS
051	2	02			FLAGS	TRIG DISP
05 2		04			ON OFF	
053		-35				DEG 🖾 FIX 🖾
054	Pi	16-24		110		
055		-24				
056		-21			3 🗆 🛛	n. <u>2</u>
	••••1111.1*		REGIS	STERS		▲ \
0	¹ LAT	² DEC OF S		5Z0HURSOF 6	ΔNS ⁷ Z∫sinHd	l⊖ ⁸ 9
L				SUNSHINE O RADI		
S0	S1	S2	S3 S4	S5 S6	S7	S8 S9
					I	
Α		В	c	D	E	I

Program Title Tempera	ature or Concentration Profile For A Semi-Infinite S	olid
Contributor's Name Hewlett	t-Packard	
Address 1000 N.E. Cir	rcle Blvd.	
City Corvallis	State Oregon Zip Code	97330
Program Description, Equations	s, Variables	· · · · · •
	Many physical situations in heat and mass transfer may be solved within engineering tolerances by assuming an infinite geometry.	
• • • • • • • •	T _a (C _a) Profile at t T _a (C _a)	
	Figure 1.	
	In Figure 1 an infinitely thick wall initially at temperature T_0 or concentration C_0 is subject to a constant surface potential T_s or C_s . At a later time t, the internal profile will have been altered by the transport of heat or mass. This program computes values of temper-	
	ature T or concentration C at time t for specified distances x from the outer surface.	
· · · · · · · · · · · · · · · · · · ·		· · · · Bulk to be and to Mad Ma Mits Mits and a deservation
and a second		
	·····	
Operating Limits and Warnings	This solution is exact for infinite configurations with constant cross sectional areas. However, finite geometries where the argument of the error function is greater than two will yield little or no error. This means transfer in finite bodies such as plates may be predicted until the effects of the step are felt on the far side. Also, geometries such as cylinders may be studied if the depth of penetration is small compared to the radius.	
	The routine used by this program will resolve error functions with arguments less than 4.5. For larger arguments, the value of the error function is set to 1.0.	

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Program Title Temper	ature or Concentration Profile For A	Semi- Infinite So	bild
Contributor's Name Hewlet	t-Packard		
Address 1000 N.E. Ci	rcle Blvd.		
City Corvallis	State Oregon	Zip Code 97	7330
Program Description, Equations	Variables		s
	Equations:		
		*	allocation is
	$T = (T_0 - T_s) \operatorname{erf} \left(\frac{x}{2\sqrt{\frac{k}{\rho c_n} t}} \right)$	+ T _s	100000.00.10
	$\left(2\sqrt{\frac{\rho c_p}{\rho c_p}}\right)$		No
	where		
	k is thermal conductivity of the material		-
	ρ is the density of the material;		and the
	c _p is the specific heat of the material;		
	$k/\rho c_p$ is also known as the diffusivity of heat	α.	
	Similarly, for mass transfer		
	/ x)	*	
	$C = (C_0 - C_s) \operatorname{erf} \left(\frac{x}{2\sqrt{Dt}}\right) + C$	S	
	where D is the mass diffusivity.		
	*erf is the error function.		
	erris the error function,		
		· · ·	
Operating Limits and Warnings			
The MIT T THE A L			
This program has been verified only	with respect to the numerical example given in Progran	Description II. User accep	ts and uses
this program material AT HIS OWN	RISK, in reliance solely upon his own inspection of the on concerning the program material.	program material and with	out reliance
	OR MAKES ANY EXPRESS OR IMPLIED WARRANTY (OF ANY KIND WITH REGAP	RD TO THIS

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Dradram Decorintian II

	i i ugi ani Descrip			
Sketch(es)		a an ann an a' ra Anna an an Anna an An		
		ου το	• • • • • • • • • • •	······································
franciska na segura se		· · · · · · · · · · · · · · · · · · ·		iaian ana i a∰a i i ini∎on non-non-nanaf
		• · • • • • • • • • • • • • • • • • • •	an den a son sensen der son kladens son kladens kan son	
· · · · · · · · ·		<u>i</u> 4	4. .	
ferra annan an cagain anns a stàinn an a				
- <u>-</u>	n an	• • • • • • • • • • • • • • • • • • •	ander a sur a contration and a set and a sure and	
	and the second			• • •
<u> </u>	nadni	:	. , .	•
	Example 1:			
	A large steel transmission shaft is case hardened	by diffusion of		
	carbon. The initial carbon concentration is 0.10%	and the surface		
	concentration is brought to 1.20% almost instan carbon concentration at 1.0 mm (1×10^{-3} m) after			
and a second	seconds), if the diffusivity of carbon in steel			
	$1.6 \times 10^{-11} \text{ m}^2/\text{s}?$			
	Keystrokes	See Displayed		
	1.6 EEX CHS 11 + 1 + 1 A 1.2 + .1 B 54000			
	C EEX CHS 3 D	► 0.59%		
······································	Example 2:			
	A furnace wall is at a constant 55°F. When the fur the inside wall temperature is raised to 2000°F. How to raise the outside wall temperature 1°F?			
	k = 0.67 Btu/hr-ft-°F			,
	Thickness = 1.5 feet			
	c = 0.2 Btu/lb °F			
	$\rho = 150 \text{ lb/ft}^3$			
	Keystrokes	See Displayed		
	An iterative solution is required since t is not a	program output.		
	Guess 5.0 hours for t.			
and all and the second se	.67 🕂 150 🕂 .2 🗛 2000 🕂 55 🖪 5 🖸 1.5 D 🛶	► 57.92°F		
······································	Guess 4.0			er en la se pueza a remembrandada
	Noting that x is stored in register 8.			
· · · · · ·	4.0 C RCL 8 D	► 55.75°F		
		► 56.04°F		
	Guess 4.18			

4.18 C RCL 8 D → 56.01°F

Noting that t is stored in register 7. RCL 7 f →H.MS → ≈4 hr. 10 min.

SEMI-INFINITE SOLID

t

×✦T(C) a✦erf(a)

S

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	To compute the error function			
	of an argument go to step 8.			
3	Input:			
	Conductivity	k		k
	<i>then</i> density	ρ		ρ
_	then specific heat	с _р		α
	or heat (or mass) diffusivity	α (D)	<u>↑</u>	α (D)
	then 1.00	1		1.00
	<i>then</i> 1.00	1	A	α (D)
4	Input:			
	Surface temperature (con-			
	centration)	T _s (C _s)		T _s (C _s)
	then initial temperature			
	(concentration)	T ₀ (C ₀)	В	T _s (C _s)
5	Input time	t	С	t
6	Input distance from surface			
	and calculate temperature			
	or concentration	×	D	т (С)
• 7	For new case go to step 2, 3, or			
	4 and change inputs. For new			
	time go to step 5. For new x go			
	to step 6.			
8	Input argument and compute			
	error function	а	E	erf(a)

	-		// i logi am			39
STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP KEY ENTRY	KEY CODE	COMMENTS
001	≭LBL A	21 11		057 +	-55	
002	X	-35	Change and the start	05 8 X≠Y?	16-32	
003	÷	-24	Store constants as	059 GTO1	22 01	
004		35 06	α or D	060 2	0 2	
005		24		061 ×	-35	
006		21 12		062 Pi	16-24	
007		35 04	Store concentrations	063 IX	54	
008		-41	or temperatures	064 ÷	-24	
009		35 05		065 RCL2	36 02	
010		24		066 2	02	
011		21 13		067 ÷	-24	
012		35 07	Store time	068 e ^x	33	
013		24		069 ÷	-24	
014		21 14		070 RTN	24	
015		35 08		071 *LBL0	21 00	
016		02		072 1	01	
017		-24		073 RTN	24	
018		36 06	Calculate temp. or			
019		36 07				
020		-35	concentration given x			
020 021		54		 		
021		-24				
022 023		23 15				
023		23 13 36 04		080		
025		36 05				
025 026		-45				
028 027		-35				
027 028						
028 029		36 0 5				
		-55				
030		24		· · · · · · · · · · · · · · · · · · ·		
031		21 15		· · · · · · · · · · · · · · · · · · ·		
032		35 01				
033		04				
034		-62		090		
035		05				
036		16-35				
037		22 00				
038		-31				
039		-21				
040		-35				
041		02 75	1	L		
042		-35				
043		35 02				
044		01		100		
045		35 03				
046		36 01				
047		21 01	Evaluate the error			
048		36 02	function			
049		36 0 3				
050		0 2			L_ 	SET STATUS
051		-55			FLAGS	TRIG DISP
052		35 <i>03</i>			ON OFF	
053		-24				DEG 😰 FIX 😡
054		36 01	1	110	1 🗆 🔎	GRAD 🗆 🛛 SCI 🗖
055		-35			2 🗆 🖵	RAD 🗆 ENG 🗆
056	ST01	35 01			3 🗆 💭	n_ <u>2</u>
				STERS		
0	¹ Part.S	$ um ^2 2a^2$		⁵ Τ _s (C _s) ⁶ α	7 t	⁸ x ⁹ Used
S0	S1	S2	S3 S4	S5 S6	S7	S8 S9
<u> </u>					l	
A		В	с	D	E	I

Program Title Transient Temperature Di	stribution In A Semi-Infinite Solid With
Convection Boundary Cond	ition
Contributor's Name Hewlett-Packard	
Address 1000 N.E. Circle Blvd	•
City Corvallis	State Oregon Zip Code 97330
)
Program Description, Equations, Variables	
Given the data_set:	
x = Depth from surface	
α = Thermal diffusivity	
k = Thermal conductivity	
h = Heat transfer coefficient	
θ = Time	
The program computes the following	ng factor $\overline{\mathbf{x}}$
$\overline{x} = ERF \frac{x}{2\sqrt{\alpha\theta}} + [EXP (\frac{hx}{k} + \frac{h^2\alpha\theta}{k^2})]$	$\frac{1}{2}$) $\frac{1}{1}$ - FRF ($\frac{1}{1}$ + $\frac{1}{2}$
$= 2\gamma\alpha\theta$ k k^2	$2\sqrt{\alpha\theta}$ k $\sqrt{3}$
where ERF = Error function	
EXP = Exponential	
	\prime compute the desired temperature T(x, θ),
according to:	
$T(x,\theta) = T_m + (T_i - T_m) \overline{x}$	
where $T_m = Sink$ temperature	
T _i = Initial solid temperat	ure
Operating Limits and Warnings	

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Sketch(es)	· ·
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	. , .
Sample Problem(s)	
For the data set:	
i of the data set.	
$x = 10^{-2}$ cm.	
$\theta = 10^{-1} \text{cm}.$	
$\alpha = 7.141 \times 10^{-3} \text{ cm}^2 \text{ sec}^{-1}$	
$k = 6.322 \times 10^{-3} \text{ cal } \text{cm}^{-1} \text{ sec}^{-1} \text{ 0}_{\text{C}}^{-1}$	
$h = 6.0 \times 10^{-1}$ cal cm ⁻² sec ⁻¹ 0 _c -1	
$r_{\rm c} = 0.0 \times 10^{\circ}$ calcin sec 0^{-1}	
Solution(s) The program computes the value:	
$\overline{\mathbf{x}} = 0.3973$	
for $T_i = 1050^{\circ}C$ and $T_{\infty} = 450^{\circ}C$	
$T(x,\theta) = T_{\infty} + (T_{\eta} - T_{\infty}) \frac{\overline{x}}{\overline{x}} = 688.40^{\circ}C$	
	Outputs:
Keystrokes:	
1[EEX][CHS] 2[STO][4] 1[EEX][CHS] 1[STO][5] 7.141[EEX]	[CHS] 3[STO][6]
6[EEX][CHS] 1[STO] [7] 6.322[EEX][CHS] 3[STO][8]	
[A][B][C][D]	-> 0.3973
1050[ENT+] 450[-][x] 450[+]	
Reference (s)	
Hockman, J.P. <u>Heat Transfer</u> Third Edition pgs. 91-96	McGraw Hill, 1972

This program is a translation of the HP-65 Users' Library program #01472A submitted by John S. Wasylyr.

τ(x,θ)		
$T(x,\theta) $		
	']	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Load program			
2.	Enter data	х	STO 4	
3.	Enter data	θ	STO 5	
	· ·			
4.	Enter data	α	STO 6	
-	P. 1			
5.	Enter data	h	<u>ST0</u> 7	
6.	Enter data	k	STO 8	
	2			See 1 below
	Press			" 2 "
8.				۷
9. 10.				" <u>3</u> " x
		$(T_i - T_{\infty})$		<u>×</u>
11.	Enter (T ₁ -T ₀)	('i ⁻ '∞/		
12.	Ducco			
12.	Press			1
13.	Enter T_	Τ _∞		
10.				
14.	Press			T(x,θ)
				1(x;0)
	For new case, go to step 2	1		
	1. Calculates $\frac{x}{2\sqrt{\alpha\theta}} + \frac{h\sqrt{\alpha\theta}}{k}$			
	2. Calculates ERF $(\frac{x}{2\sqrt{\alpha\theta}} + \frac{h\sqrt{\alpha\theta}}{k})$			
	3. Calculates & Stores:			
	3. Calculates & Stores: R8 = ERFC ($\frac{x}{2\sqrt{\alpha\theta}} + \frac{h\sqrt{\alpha\theta}}{k}$ EXP ($\frac{hx}{k} + \frac{h^2\alpha\theta}{k^2}$			
	$\frac{1}{2\sqrt{\alpha}\theta}$ k k k k			
	X			
	ERF ($\frac{1}{2\sqrt{\alpha\theta}}$) in stack			

				~	B						43
STEP	KEY ENTRY	KEY CODE		COMM	ENTS	STEP	KEY ENTRY	•	KEY CODE	COM	MENTS
001	*LBLA	21 11				057	*LBLC		21 13	Calc	
002	RCL8	36 08				058			01	$\frac{x}{\text{ERFC}(\frac{1}{2\sqrt{\alpha\theta}})}$	h.
003	ST÷7	35-24 07	Calc	(h/k)	Sto R-7	059	X‡Y		-41	ERFC(2./a	= + <u></u>
004		36 66				060	-		-45		ĸ
005		35-35 05	Calc	(αθ) S	Sto R-5	061	STOS		35 08 - '	Store R-8	
00E		36 04				062	RCL7		36 07 - '		
667		36 07				863			36 05		
008		-35				864			54		
009		35 06	Calc	(hx/k)) Sto R-6	065			-35		
010		36 04				86 6			53		h20
011	2	<i>02</i>				<i>067</i>			36 06	Calc (<u>hx</u> EXP (<u>k</u>	$+\frac{n^{-}x\theta}{1}$
012		-24				068			-55	EXP K	K- /
013		36 05				069			33		
014		54				070			36 08	Calc (EXP)(ERFC)
815		-24				071			-35	Sto R-8	
016		35 04	Calc	(4/2)	œ) Sto R-4				35 08		
017		36 07	Joure	(7/ 2/		073	RCL4		36 04	Calc. ERF	$(-\hat{-})$
018		36 05			:	074			22 12	Curc. En	`2ναθ '
019		54				075			24	ł	
010 020		-35	1			876	*LBLD		21 14		
020		-55	Calc	(x/2√a	θ + h√αθ/μ)	076 077	RCL8		36 08	Calc	
022		24			ĸ	078			-55	ERF + (EXP)(ERFC)
023		21 12				079			24		
024		35 01				080		1	- (
024		-21	Calc					+			
026		-35			$h\sqrt{\alpha A}$	ł		+			
027		02	ERF ()	1/2 Jan	+ ^{h√αθ} /k)	┝╌───╂		+			:
029		-35		2100	r	┣─────┣		+			
020		35 02				+		+			
038		00 02 01						+			
031		35 03						-			
032		36 01					· · ·	+			
033 033		21 01									
033 034		36 02				090		+			
835		36 02 36 03				090		+			
035 036		36 8 3 8 2				<u> </u>		+			
032 037		-55						+			
038						└─── ┤		-			
030 039		35 03						+		-	
039 040		-24						-			
040 041	X	36 01 -35							·····		
041 042		-35 35 01	ł			┝───╁		+		1	
042 043		33 01 -55				┝───┤		+		4	
043 044		-55 16-32	1			100		+		1	
844 845		22 01	1					+-		4	
84J 846		02	1			┝───┼		+			
040 047		-35	1			╞		+		4	
047 048		-35 16-24	1			┝────┼		+		4	
048 049		16-24 54	1			├ ───┤		+		ł	
04 <i>3</i> 050		36 02	1			┝		+- r		SET STATUS	
050 051	RULZ 2	36 02 02	1			┝──┤		┼╋			
· 051		-24	1			├		╇	FLAGS	TRIG	DISP
053		-24 33	ł			┝───┤		┾╼╢		DEG DX	FIX 🛛
033 054		-35	1			110		+	0 🗆 🛛 🕅 1 🗆 🖓	GRAD	
054 055		-35 -24	1					+	2 0 03		
055 056		-24 24	1			┝───╂		+	3 🗆 🖄		n
030	K (N	24	L		PECIS	STERS		<u></u>		<u> </u>	
0	1 11	d ² Ucod	3 11	cod	4	5	6 θ		⁷ h	⁸ k	⁹ Used
ľ	¹ Use	d ² Used		sed	* X	γ α	U U		<u> </u>		1
S0	S1	S2	S 3		S4	S5	S6		S7	S8	S9
A		В		С		D		Е		I	

Program Title Conservation of Energy	
Contributor's Name Hewlett-Packard Address 1000 N.E. Circle Blvd.	
City Corvallis State Or	egon Zip Code 97330
Program Description, Equations, Variables	
These cards convert kinetic energy, potential en volume work to energy. Card 1 is for English u is for SI or metric units. Energy is stored as a run- ning total. When a zero is displayed, pressing the keys will cause the running total to be converted velocity, height, pressure or energy per unit mass. used in a large number of fluid flow problems, who tion and pressure change along the path of flow.	B, C, D or E d to an equivalent The cards may be
Operating Limits and Warnings	
Downstream values should be input as neg output is called for, the calculator displays regard to upstream or downstream location	the relative value with no
Flashing zeros will result when the total ene 8 is negative and an attempt is made to calc	
<u></u>	

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CONSERVATION OF ENERGY

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City

Program Title

Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables

 $\frac{v_1^2}{2} + gz_1 + \frac{P_1}{\rho} + \frac{E_1}{\dot{m}} = \frac{v_2^2}{2} + gz_2 + \frac{P_2}{\rho} + \frac{E_2}{\dot{m}}$

where

v is the fluid velocity;

z is the height above a reference datum;

P is the pressure;

E is an energy term which could represent inputs of work or friction loses (negative value);

- g is the acceleration of gravity;
- ρ is the fluid density;
- m is the mass flow rate (assumed to be unity);

subscripts 1 and 2 refer to upstream and downstream values respectively.

Operating Limits and Warnings

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		en la successione de la seconda de la sec
Sample Problem(s)	Example 1:	
	A water tower is 100 feet high. What is the zero	flow rate pressure at
and a paper of the second s	the base? The density of water is 62.4 lb/ft^3 .	
and a start of the	Keystrokes	See Displayed
	Using card 1	
	62.4 A 100 C D	→ 43.33 psig
and the second	If water is flowing out of the tower at a velocity	
	the static pressure?	-
1 1 1	10 CHS B D	> 42.66 psig
	What is the maximum frictionless flow veloc	ity which could be
and a subsection of the sector	achieved with the 100 foot tower?	
and a second	If 10000 pounds of water are pumped to the top	
	hour, at a velocity of 20 ft/sec, with a frictiona psi, how much power is needed at the pump?	Il pressure drop of 2
	62.4 A 20 B 2 D 100 C E	→ 0.14 Btu/lb
Solution(s)	10000 🕱	
		(Btu/hr)
a an		
properties and the full control of the data of the second s		
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Reference (s)		
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Sketch(es)	. <u>.</u>			iy o o wagina aya namooya waxaa kata ka
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Sample Problem(s)	Example 2:			
And a strate of a second state water and	An incompressible fluid (0	= 735 kg/m ³) flows	through the conver	[-
waaraaaaaaaaaaaaaaaaaaaa ahaa ahaa ahaa	size meaning of Figure 1	At noint I the velo	city is 5 m/s and a	
and a second	point 2 the velocity is 15 points 1 and 2 is 3.7 meter	m/s The elevation	difference betwee	11
	points 1 and 2 is 3.7 meter static pressure difference be	etween points 1 and 2	2?	
versal, Navya,	static pressure difference of	▲		
un en en angelan angelan an a				
1999 - F. F. H.				
an a sha a				-
	 3 m/s1			
n an dada ana an				m
	-+ -+		2	
a analysis of a second se			15 m/	
ad MM R man a		Figure 1.		•
	<u> </u>			
Solution(s)	······································			
111 (Maran Mala), A.S. & Joy et A.S. 10 - 10	Keystrokes		See Displayed	1.100 - 1.00 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100
	Using card 2			
		_		
	735 A 3 B 3.7 C 15 CHS B	D	- −52710.82 (Nt/m²)	
and the second second			(141/111-)	
Mar a management of the second s			+	
				· · · · · · · · · · · · · · · · · · ·
<u></u>				
Reference (s)				
l				

	Program I	Description II	
Sketch(es)			
<u></u>			
Sample Problem(s)			
Sample Problem(s)	Example 3:		
	A reservoir's level is 25 meter 85% power generation efficien with a flow rate of 20 m ³ /s?	s above the discharge pond. Assuming icy, how much power can be generated	
	ho =]	1000 kg/m ³	
	Keystrokes	See Displayed	
	Using card 2		
	1000 A 25 C E	→ 245.17	
	.85 🗙	(joule/kg) ─────────────────────── 208.39	
		(joule/kg)	
		→ 20000 (kg/s)	
	×	► 4167826.25	
·		(watts)	
Solution(s)			
Reference (s)			

/	CONSERVA	TION OF EI	NERGY-ENC	GLISH		
8	ρ(START) (Ib/ft ³)	(ft/sec)	ž (ft)	p (psi)	(Btu)	

	CONSER	VATION O	F ENERGY-	SI		
	ρ(START) (kg/m ³)	v (m/s)	ž (m)	(N/m ²)	(J/kg)	
6	((1			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	For English units (pounds, feet,			
	seconds, Btus), enter			
	Card 1. for SI units			
	(kilograms, meters, seconds,			
	watts), enter Card 2			
2	Input fluid density	ρ	A	g
3	Input the following (negative			
	values are downstream values):			
	Fluid velocity	v	В	0.00
	Height from reference datum	z	С	0.00
	Pressure	Р	D	0.00
	Energy input	E	E	0.00
4	Repeat step 3 for all input			
	values			
5	Calculate the unknown:			
	Fluid velocity	0.00	В	v
	Height from reference datum	0.00	с	Z
	Pressure	0.00	D	Р
	Energy	0.00	E	E
6	For new case go to step 2, or			
	store 0.00 in register 8 and go			
	to step 3.			

)	·		7/ 1 logian			L		
бтің 📜	KEYENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS	
001	*LBLA	21 11		857		22 01		
002		35 04		058	RCL8	36 08		
003		-51		059	RCL7	36 0 7		
004		3 5 08		860	÷	-24		
005	7	07		061	RCL4	36 04		
006		07		862	X	-35		
007	8	08	Store ρ and	863	RCL6	36 06		
008	•	-62	constants	064	÷	-24		
889	1	01		865	RTN	24		
01Ē		06		066		21 15		
011	ST05	35 05		867	ENTT	-21		
012		03		968	RCL5	36 05		
013	32	02		869	Σ	-35		
014	_	-62		070	RCL6	36 06		
015	1	01 01		871	X	-35		
016	7	87		072		00	Energy	
017		35 06		072		16-32	Ellergy	
018								
		24		874	GT01	22 01		
019 828		21 12	1	075		36 08 36 05		
B20	ENTT	-21		076		36 05		
821	ABS	16 31	Velocity	677		-24		
022	×	-35		078		36 06		
e23		02		879		-24		
024	÷	-24		080	RTN	24		
025	Ũ	ØŬ]	081		21 01		
026	X≠Y?	16-32		882		-31		
027		22 01		083		35-55 08	Summation	
028		36 08		084		80		
029		02		085		24		
830		-35				1	1	
031	18	54					•	
Ø32		24					ł	
633 633		21 13		J			4	
034		-21					4	
				090			ł	
035 076		36 06						
Ø36		-35						
837		00	Height					
038		16-32						
0 39		23 01						
040		36 08		•				
041	RCLE	36 06					1	
042	÷	-24					1	
843	RTN	24	1				1	
844		21 14	1	100			1	
845		-21	1				1	
04E		<u>ē</u> 1	1	┣			4	
047		Ũ4	1	+-			4	
048		04 04	1				4	
849		35 07		∔			ł	
649 656							4	
		-35 76 04					4	
051 050	RCL4	36 04	Pressure				4	
052 057		-24					1	
053		36 06	1				4	
054		-35	1	110			4	
Ø55		00						
056	X≠Y?	16-32	1					
•			REC	GISTERS				
	1	2	3 4	5 778.16	6	7	8 9 ΣE Used	
	S1		ρ 	S5	5 g S6	S7	S8 S9	
	<u> </u>	В	C	D		E	I	

STE	EP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMM	ENTS
	001	*LBLA	21 11		057		-31	Summation	
	002	ST04	35 04	Channel and state	058		35-55 08		
	003	CLX	-51	Store and gravity			00		·
	004	STO8	35 08	constant	068	RTN	24	i i	
	005	9	09]	
	006		-62]	
	007	8	08						
	008	0	66]	
	009	6	0 6					1	
	010	6	06 06		t i			1	
	011	5	00 05					1	
	012	STO6	35 06		180			1	
	013	RTN	24					1	
	013	*LBLB	21 12					1	
	014							1	
		ENT†	-21					4	
	016	ABS	16 31					-	
	017	×	-35		┝ ┨		+	1	
	018	2	02		┝			1	
	019	÷	-24	Velocity	┝			4	
	820	0	00		┝──┤		+	4	
	821	8≢Y?	16-32		190			4	
	022	GT01	22 01		190			-	
	023	RCLS	36 08					4	
	024	2	02		L		- -	4	
	825	Х	-35					1	
	026	18	54					1	
	027	RTN	24						
	628	*LBLC	21 13						
	029	ENTT	-21						
	030	RCL6	36 86						
	631	х	-35	Height					
	032	Ø	00		200				
	833	X≠Y?	16-32						
	034	GT01	22 01						
	035	RCL8	36 08						
	036	RCLE	36 06						
	037	÷	-24					1	
	038	RTN	24			1000	1	†	
	839	*LBLD	21 14					1	
	040	ENTT	-21					1	
	041	RCL4	36 04					1	
	042	÷	-24		210				
	843	0	00					1	
	043 044	X≢Y?	16-32	Phoseumo			1	1	
	044 045	6701	16-32 22 01	Pressure			1	1	
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