HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Cardiac

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 Programming Guide,** "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the 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

CARDIAC PROGRAM SERIES

The following programs may be used in a series to carry out the many calculations in a particular medical procedure. Following are examples from an adult cath lab and a pediatric cath lab. These examples are fairly complicated. Before attempting them, read over the detailed instructions for each of the programs and try the included examples. In these examples, values stored in memory for later use are underlined. When recalled from memory (so that they do not need to be reentered), they are enclosed in brackets.

Adult Cath Lab Example:

Note that cardiac output, calculated in DYE CURVE CARDIAC OUTPUT is used in BODY SURFACE AREA and VALVE AREA and STROKE WORK. BODY SURFACE AREA, calculated by the Du Bois method, is used in STROKE WORK.

Program		
DYE CURVE CARDIAC OUTPUT	Δt = 1 sec.; DC = 38, 67, 80, 73, 61, 48, 36, 29 Div; CAL = 0.11 mg/1/Div; DOSE = 5.6 mg	AREA = 532.60 Div sec; CAL X AREA = 58.59 mg/1; <u>CO = 5.73 1/min</u>
BODY SURFACE AREA (Du Bois)	Ht.= -72.1 in., Wt.= -191 lb. (CO)	Ht. = 183.13 cm; Wt. = 86.82 kg. <u>BSA = 2.09 m^2</u> CI = 2.74 1/min/m^2
VALVE AREA (Aortic)	SEP = 0.2 sec; ΔP = 38, 45, 40, 31 mmHg; R-R = 0.92 sec. (CO)	ΔP = 38.50 mmHg; AREA = 1.59 cm^2
VALVE AREA (Mitral)	DFP = 0.55 sec; ΔP = 10, 12, 8, 6, 2 mmHg; R-R = 0.94 sec; (CO)	ΔP = 7.60 mmHg; AREA = -1.90 cm^2
STROKE WORK	P_{sys} = 155, 169, 165, 152, 138 mmHg; R-R = 0.92 sec; (CO) (BSA)	ΔP = 155.80 mmHg; SW = 186.17 gm · m; SWI = 88.95 gm · m/m^2
CONTRACTILITY	t = 0.01 sec; P_N = 14.8, 28.5, 51.7, 81.8, 105.6	MAX dP/dt = 3010 mmHg/sec; MAX dP/dt/P = 63.3 sec; V_{MAX} = 2.49 circ/sec.

Pediatric Cath Lab Example:

Note that body surface area calculated in BODY SURFACE AREA (Boyd) is used in FICK Cardiac output. Venous oxygen content, calculated the first time O_2 SATURATION and CONTENT is run, is used in FICK. Hemoglobin, entered the first time SAT is run, automatically reappears the second time. Especially note that arterial oxygen content is left in the display the second time SAT is run, and is ready as the first entry in FICK. This is another method of transferring data between programs.

Program		
BODY SURFACE AREA (Boyd)	Ht. = 55 cm; Wt = 4.2 kg	BSA = 0.26 m^2
O_2 SATURATION and CONTENT	PO_2 = 30 mmHg;	Est. Sat. = 57.18%
(Venous)	Sat.=55%; Hgb = 18gm/100ml	C_vO_2 = 13.36 Vol.%
O_2 SATURATION and CONTENT	PO_2=52 mmHg; Sat.=84.5%	Est. Sat. = 86.86%
(Arterial)	(Hgb)	CaO_2 = 20.54 Vol.%
FICK CARDIAC OUTPUT	(CaO_2); (C_vO_2); VO_2 = 60 ml/min (BSA); HR = 95 BPM	CO = 0.84 l/min CI = 3.15 l/min/m^2 SV = 8.74 ml; SI = -33.14 ml/m^2
ANATOMIC SHUNTS	R-SYST = 55%; R-PUL = 62% L-SYST = 84.5%; L-PUL = 97%	L-R SHUNT = 16.67% R-L SHUNT = -29.76%

Program Description I

Program Title VIRTUAL PO_2 AND O_2 SATURATION AND CONTENT

Contributor's Name Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables The first part of this program computes virtual PO_2 for use in estimating O_2 saturation. Generally, it will be more convenient to calculate venous values first, as arterial values are frequently needed in other programs and, thus, will be left in the storage registers after both calculations.

The equation solved is

$$VPO_2 = PO_2 \cdot 10^{[0.024(37-BT) + 0.48(pH-7.4) + 0.06(\log PCO_2)]}$$

which is a hybrid of the equation used by Thomas and that used by Kelman. There is some disagreement regarding the best value of the pH multiplier, 0.48 being used by most workers, but see, for example, Kelman.

The second part of the program estimates O_2 saturation of blood from virtual PO_2 and computes O_2 content. If the actual O_2 saturation is known, O_2 content may be computed directly.

Equations:

The part of the program for estimating O_2 saturation is based on the polynomial curve fit of Thomas, where VPO_2 is in mmHg.

$$O_2 \text{ Sat} = \frac{(VPO_2)^4 - 15(VPO_2)^3 + 2045(VPO_2)^2 + 2000(VPO_2)}{(VPO_2)^4 - 15(VPO_2)^3 + 2400(VPO_2)^2 - 31{,}100\ (VPO_2) + 2{,}400{,}000}$$

This calculation assumes that the oxygen dissociation curve for the hemoglobin is normal. The O_2 content is computed from

$$C_xO_2 \text{ (Vol.\%)} = 1.34 \cdot \frac{\text{SAT(\%)}}{100} \cdot \text{Hgb(g/100ml)} + 0.0031\ PO_2 \text{ (mmHg)}$$

Operating Limits and Warnings Virtual PO_2 is not in any way a real physiologic PO_2. Its only function is for use in estimating O_2 saturation, and it should never be confused with PO_2 corrected to body temperature. Furthermore, it must always be calculated from blood parameters measured at or corrected to 37°C. The calculation will give inaccurate results for fetal hemoglobin, present in babies less than six months old, and for some abnormal adult hemoglobins and certain other blood conditions. The results of the estimation and any subsequent calculations based on it, should be viewed with caution unless the dissociation curve has been previously established to be normal. If both PO_2 and O_2 saturation are measured, the program may be used as a convenient means to check for the normality of the dissociation curve.

DETAILED USER INSTRUCTIONS:

Input PO_2, PCO_2, and pH measured at 37°C. Input body temperature in degrees C. If PO_2 has been previously input, recall it by pressing [f] [A] then press [f] [B]. Otherwise, input PO_2 and press [f] [B]. For each variable after PO_2, stored values will be recalled. If none have been input, recalled values will generally be zero. It is important to input pH and body temperature exactly, as these have a great influence on the calculation of virtual PO_2. Errors, especially in body temperature, can result in large errors in VPO_2 and, hence, estimated saturation. PCO_2 has relatively little influence. Press the buttons from left to right and do not skip any. The virtual PO_2 remains in the display for immediate entry in calculation of O_2 saturation and content. It is not stored in place of the measured PO_2. The PO_2, PCO_2, and pH remain in memory. Note that separate storage registers are not maintained for arterial and venous values, only the most recent ones will be stored.

To compute O_2 content, input the PO_2, O_2 saturation, and hemoglobin concentration. After PO_2 is input, an estimated O_2 saturation is calculated, based on a standard dissociation curve. This will only be meaningful if a virtual PO_2 (VPO_2) from the first part of the program is input. The estimated O_2 saturation may be accepted simply by pressing [B], or a measured value can be input. If Hgb was previously input, it will be recalled. If the calculated O_2 content is to be stored as arterial or venous for later use in Fick cardiac output or physiologic shunt calculations, press the appropriate button. Regardless of which content is computed first, CaO_2 is left in the display for convenience in case the ANATOMIC SHUNTS program is to be run next.

If O_2 saturation of blood is to be estimated from PO_2, it is important to input the virtual PO_2 calculated in the first part of the program. A large error can result from inputting measured PO_2 without the corrections. The program may be used to compare estimated O_2 saturation with measured O_2 saturation, to obtain a rough idea of the variation of the dissociation curve from normal. This will be especially sensitive with partly unsaturated venous blood where the slope of the curve is fairly steep. When computing content for purposes of estimating physiologic shunt and Fick cardiac output, it is always best to measure the saturation. Small variations in the dissociation curve can cause considerable error in the shunt and cardiac output calculations and because the effect is not the same on venous blood as on the higher saturation arterial blood.

The calculated O_2 content includes both the dissolved oxygen and the hemoglobin bound oxygen. If only O_2 saturation was measured, and not PO_2, an estimated PO_2 should be input to obtain the maximum accuracy in the content calculation. The estimate for PO_2 need only be rough as the effect is very small, unless the patient is breathing an oxygen-enriched atmosphere and PO_2 is well above 100 mmHg.

To compute equivalent alveolar blood O_2 content, enter the equivalent P_AO_2, rather than the virtual PO_2. The P_AO_2 can be calculated by the A-aO_2 DIFFERENCE program. In this case, the resulting O_2 content should not be stored as either arterial or venous, but simply left in the display register for use at the beginning of the PHYSIOLOGIC SHUNT AND FICK programs which should be executed next. Thus, the over-all sequence should be to compute venous content first, arterial content second, and alveolar content last. The PHYSIOLOGIC SHUNT AND FICK program may then be run without having to enter any new O_2 content data.

Program Description II

Sketch(es)

Sample Problem(s)

1) For the following patient data calculate virtual PO_2 and from it estimated O_2 saturation and O_2 content. Store the value as venous O_2 content.

PO_2 = 75 mmHg
PCO_2 = 45 mmHg
pH = 7.35
BT = 40°C
Hgb = 16 gm/100 ml

2) Calculate est. O_2 saturation and O_2 content assuming the PO_2 was actually 75 mmHg.

Solution(s)

1) 75 [f] [B] 45 [f] [C] 7.35 [f] [D] 40 [f] [E] → 59.71 mmHg VPO_2
[A] → 90.92 est. SAT%
[B] 16 [C] → 19.68 O_2 Content %
[E] → 0.00
(19.68% stored as venous O_2 content. No previously stored arterial O_2 content is present.)

2) [f] [A] [A] → 95.08 est SAT%
[B] [C] → 20.62 O_2 Content

Reference(s)

Thomas, L.J. Jr., "Algorithms for Selected Blood Acid-Base and Blood Gas Calculations," J. Appl. Physiol. 33: 154-158, 1972

Kelman, G. Richard, "Digital Computer Subroutine for the Conversion of Oxygen Tension into Saturation," J. Appl. Physiol. 21: 1375-1376, 1966.

This program is a modification of the Users' Library Programs # 00196A and # 00197A submitted by Hewlett-Packard.

User Instructions

1 VIRTUAL PO_2 AND O_2 SATURATION AND CONTENT 2

RCL PO_2	PO_2	PCO_2	pH	BT→VPO_2
VPO_2, P_AO_2	SAT	Hgb→Cont	CaO_2	CvO_2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load side 1 and side 2	PO			
2	If PO_2 was previously input, recall it		f	A	PO_2 (mmHg)
3	INPUT PO_2 if not recalled in step 2	PO_2 (mmHg)	f	B	PCO_2 (if stored)
4	INPUT PCO_2 if not recalled in step 3	PCO_2 (mmHg)	f	C	
5	INPUT pH if not recalled in step 4	pH	f	D	pH (if stored)
6	INPUT BT if not recalled in step 5				BT (if stored)
	and calculate virtual PO_2	BT (°C)	f	E	
7	INPUT virtual PO_2 from previous step or				
	alveolar P_AO_2	VPO_2 or P_AO_2	A		est. SAT (%)
8	INPUT est. SAT% from step 2 and recall Hgb				
	if previously stored (use actual SAT				
	if known)	est. SAT%	B		Hgb (if stored)
9	INPUT Hgb	Hgb (g/100ml)	C		CxO_2 (Vol%)
10	If calculated O_2 content is to be stored				
	as arterial	CaO_2 (Vol%)	D		CaO_2 (Vol%)
	or as venous	CvO_2 (Vol%)	E		CaO_2 (Vol%)

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	RCL5	36 05	Recall PO_2
003	FRC	16 44	
004	EEX	-23	
005	3	03	
006	x	-35	
007	RTN	24	
008	*LBLb	21 16 12	
009	EEX	-23	
010	3	03	Input PO_2
011	STO8	35 08	and recall PCO_2
012	÷	-24	
013	STO1	35 01	
014	RCL5	36 05	
015	EEX	-23	
016	2	02	
017	÷	-24	
018	RTN	24	
019	*LBLc	21 16 13	
020	EEX	-23	Input PCO_2
021	2	02	and recall pH
022	x	-35	
023	INT	16 34	
024	RCL1	36 01	
025	+	-55	
026	STO5	35 05	
027	RCL6	36 06	
028	RCL8	36 08	
029	÷	-24	
030	RTN	24	
031	*LBLd	21 16 14	
032	RCL8	36 08	
033	x	-35	Input pH
034	INT	16 34	
035	STO1	35 01	
036	RCL6	36 06	
037	FRC	16 44	
038	RCL8	36 08	
039	x	-35	
040	RTN	24	
041	*LBLe	21 16 15	
042	ENT↑	-21	
043	ENT↑	-21	
044	RCL8	36 08	
045	÷	-24	
046	RCL1	36 01	
047	+	-55	
048	STO6	35 06	Calculate VPO_2
049	RCL8	36 08	
050	÷	-24	
051	7	07	
052	.	-62	
053	4	04	
054	-	-45	
055	4	04	
056	8	08	
057	x	-35	
058	X⇄Y	-41	
059	3	03	
060	7	07	
061	-	-45	
062	2	02	
063	.	-62	
064	4	04	
065	x	-35	
066	-	-45	
067	4	04	
068	EEX	-23	
069	3	03	
070	RCL5	36 05	
071	÷	-24	
072	LOG	16 32	
073	6	06	
074	x	-35	
075	+	-55	
076	EEX	-23	
077	2	02	
078	÷	-24	
079	10^x	16 33	
080	GSBa	23 16 11	
081	x	-35	
082	PRTX	-14	VPO_2
083	RTN	24	
084	*LBLA	21 11	
085	STO1	35 01	Input VPO_2
086	ENT↑	-21	and calculate
087	x	-35	estimated SAT
088	STO8	35 08	
089	ENT↑	-21	
090	x	-35	
091	RCL8	36 08	
092	RCL1	36 01	
093	x	-35	
094	1	01	
095	5	05	
096	x	-35	
097	-	-45	
098	ENT↑	-21	
099	ENT↑	-21	
100	RCL8	36 08	
101	2	02	
102	4	04	
103	0	00	
104	0	00	
105	x	-35	
106	+	-55	
107	X⇄Y	-41	
108	RCL8	36 08	
109	2	02	
110	0	00	
111	4	04	
112	5	05	

REGISTERS

0	1 Used / PO_2	2	3 CvO_2	4 CaO_2	5 Used	6 Used	7	8 Used / SAT	9 Hgb
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	x	-35	
114	+	-55	
115	RCL1	36 01	
116	2	02	
117	EEX	-23	
118	3	03	
119	x	-35	
120	+	-55	
121	X⇄Y	-41	
122	RCL1	36 01	
123	3	03	
124	1	01	
125	1	01	
126	0	00	
127	0	00	
128	x	-35	
129	-	-45	
130	2	02	
131	4	04	
132	EEX	-23	
133	5	05	
134	+	-55	
135	÷	-24	
136	EEX	-23	
137	2	02	
138	x	-35	
139	ST08	35 08	Est. SAT
140	PRTX	-14	
141	RTN	24	
142	*LBLB	21 12	Input SAT
143	ST08	35 08	
144	RCL9	36 09	
145	RTN	24	
146	*LBLC	21 13	
147	ST09	35 09	Calculate Content
148	RCL8	36 08	
149	1	01	
150	3	03	
151	4	04	
152	x	-35	
153	x	-35	
154	RCL1	36 01	
155	3	03	
156	1	01	
157	x	-35	
158	+	-55	
159	EEX	-23	
160	4	04	
161	CHS	-22	
162	x	-35	
163	PRTX	-14	
164	RTN	24	
165	*LBLD	21 14	Store CaO_2
166	ST04	35 04	
167	RTN	24	
168	*LBLE	21 15	
169	ST03	35 03	Store CvO_2
170	RCL4	36 04	Recall CaO_2
171	RTN	24	
172	R/S	51	

180

190

200

210

220

LABELS

A	B	C	D	E
PO_2	SAT	Hgb	CaO_2	CvO_2
a PO_a	b PO_2	c PCO_2	d pH	e VPO_2
0	1	2	3	4
5	6	7	8	9

FLAGS

0
1
2
3

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

Program Description I

Program Title BODY SURFACE AREA FOR CARDIO PULMONARY

Contributor's Name Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables This program calculates body surface area by either the method of DuBois or the method of Boyd. In both cases, the required inputs are height and weight, which may be input either in metric (cm, kg) or English (in., lb.) units. Quantities in English units should be input as negative numbers. If cardiac output is given, the cardiac index can also be calculated.

Equations:

Let Ht be height, Wt be weight, and BSA be the body surface area in m^2.

$$\text{Ht (cm)} = 2.54 \text{ Ht (in.)}$$

$$\text{Wt (kg)} = 0.45359237 \text{ Wt (lb.)}$$

DuBois:

$$\text{BSA } (m^2) = \text{Ht (cm)}^{0.725} \cdot \text{Wt (kg)}^{0.425} \cdot 7.184 \times 10^{-3}$$

Boyd:

$$\text{BSA } (m^2) = \text{Wt (g)}^{(0.7285 - 0.0188 \log \text{Wt})} \cdot \text{Ht (cm)}^{0.3} \cdot 3.207 \times 10^{-4}$$

$$\text{CI} = \frac{\text{CO (l/min)}}{\text{BSA } (m^2)}$$

Operating Limits and Warnings The DuBois formula for BSA is undefined for children with a BSA less than 0.6 m^2. In such cases BSA should be calculated by the Boyd formula.

Program Description II

Sketch(es)

Sample Problem(s) 1) Patient is 176 cm in height and weighs 63.5 kg. What is his body surface area by both the DuBois and Boyd methods?

2) A patient 60 inches in height and 100 pounds in weight has a cardiac output of 5 l/min. Calculate the body surface area and cardiac index by DuBois. What is the cardiac index using the Boyd BSA?

Solution(s)

```
1)  176 [A] 63.5 [B] [C] → 1.78 m² (DuBois)
                     [D] → 1.76 m² (Boyd)

2)  60 [CHS] [A] 100 [CHS] [B] [C] → 1.39 m² (DuBois)
                             5 [E] → 3.59 l/min m² (CI, DuBois)

                               [D] → 1.40 m² (Boyd)

                           [f] [E] → 5.00 (Recalls CO, Stored above)
                               [E] → 3.57 l/min m² (CI, Boyd)
```

Reference(s)

D. DuBois and E.F. DuBois, Clin. Cal. 10, Arch. Int. Med., 17,863,1916.

Edith Boyd, Growth of the Surface Area of the Human Body, U. of Minnesota Press, 1935, p. 132.

This program is a modification of the Users' Library Programs # 00203A and # 00204A submitted by Hewlett-Packard.

User Instructions

1 BODY SURFACE AREA for CARDIO PULMONARY 2

Height	Weight	DuBois	Boyd	RCL CO CO → CI

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load Sides 1 and 2				
2	Input Patient Height	Ht (+cm or -in)	A		Ht (cm)
3	Input Patient Weight	Wt (+kg or -lb)	B		Wt (kg)
4	Calculate BSA: By DuBois		C		BSA (m^2)
	By Boyd		D		BSA (m^2)
5	Recall cardiac output (if previously stored)		f	E	CO (l/min)
6	Input CO and calculate CI	CO (l/min)	E		CI(l/min m^2)

DETAILED USER INSTRUCTIONS

The height and weight may be input in either metric or English units. If English units are used, they must be input as negative values. This is accomplished by pressing [CHS] after the number is input, but before the program button is pressed. The metric equivalent will appear in the display.

Press [C] or [D] to obtain body surface area, which will also be stored in the calculator's memory. If cardiac output has been previously calculated, it may be recalled by pressing [f] [E]. Alternatively, it may be input. In either case, pressing [E] will yield cardiac index by means of the last body surface area calculated.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter Ht.
002	X>0?	16-44	If cm store
003	GTO1	22 01	
004	CHS	-22	If inches, convert
005	2	02	to cm and store
006	.	-62	
007	5	05	
008	4	04	
009	x	-35	
010	*LBL1	21 01	
011	STO5	35 05	Store Ht.
012	RTN	24	
013	*LBLB	21 12	Enter Wt.
014	X>0?	16-44	If kg store
015	GTO2	22 02	
016	CHS	-22	If lbs., convert
017	2	02	to kg and store
018	.	-62	
019	2	02	
020	÷	-24	
021	*LBL2	21 02	
022	STO6	35 06	Store Wt.
023	RTN	24	
024	*LBLC	21 13	Calculate BSA
025	RCL5	36 05	by DuBois
026	.	-62	
027	7	07	
028	2	02	
029	5	05	
030	Y^x	31	
031	RCL6	36 06	
032	.	-62	
033	4	04	
034	2	02	
035	5	05	
036	Y^x	31	
037	x	-35	
038	1	01	
039	3	03	
040	9	09	
041	.	-62	
042	2	02	
043	÷	-24	
044	STO1	35 01	
045	EEX	-23	Tangle with CO
046	2	02	and store as
047	÷	-24	100 CO + .01 BSA
048	RCL7	36 07	
049	INT	16 34	
050	+	-55	
051	STO7	35 07	
052	RCL1	36 01	
053	PRTX	-14	
054	RTN	24	
055	*LBLD	21 14	Calculate BSA
056	RCL5	36 05	by Boyd
057	.	-62	
058	3	03	
059	Y^x	31	
060	RCL6	36 06	
061	EEX	-23	
062	3	03	
063	x	-35	
064	ENT↑	-21	
065	LOG	16 32	
066	.	-62	
067	0	00	
068	1	01	
069	8	08	
070	8	08	
071	x	-35	
072	.	-62	
073	7	07	
074	2	02	
075	8	08	
076	5	05	
077	-	-45	
078	Y^x	31	
079	÷	-24	
080	3	03	
081	1	01	
082	1	01	
083	8	08	
084	÷	-24	
085	STO1	35 01	
086	EEX	-23	Tangle with CO
087	2	02	and store as
088	÷	-24	100 CO + .01 BSA
089	RCL7	36 07	
090	INT	16 34	
091	+	-55	
092	STO7	35 07	
093	RCL1	36 01	
094	PRTX	-14	
095	RTN	24	
096	*LBLe	21 16 15	Untangle and
097	RCL7	36 07	recall CO
098	EEX	-23	
099	2	02	
100	÷	-24	
101	RTN	24	
102	*LBLE	21 15	Calculate CI
103	EEX	-23	untangle CO with
104	2	02	BSA and store
105	x	-35	
106	INT	16 34	
107	RCL7	36 07	
108	FRC	16 44	
109	+	-55	
110	STO7	35 07	
111	LSTX	16-63	
112	÷	-24	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	BSA				HT.	WT.	Used		

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	EEX	-23	
114	4	04	
115	÷	-24	
116	PRTX	-14	
117	RTN	24	
118	R/S	51	
120			
130			
140			
150			
160			
170			
180			
190			
200			
210			
220			

LABELS

A	B	C	D	E
Ht.	Wt.	DuBois	Boyd	CI
a	b	c	d	e RCL CO
0	1 Sto. Ht.	2 Sto. Wt.	3	4
5	6	7	8	9

FLAGS

0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

Program Description I

Program Title DYE CURVE CARDIAC OUTPUT

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program computes the area of the first part of the curve by trapezoidal rule integration. The part after the last point is calculated from an exponential projection based on the first measured point below 65% of the peak measured point; and the first measured point after that which is below 45% of the peak. This not only avoids problems of indicator recirculation in most cases, but also limits the amount of data to be input. Thus it is important to have a measured point which is below 45% of the peak, but before recirculation becomes obvious. If this isn't possible, an approximation can be obtained by guessing at the curve without recirculation and entering these values.

Equation Used:

$$\mathrm{CO}(l/\mathrm{min}) = \frac{\mathrm{DOSE\ (mg)} \cdot 60\ (\mathrm{sec/min})}{\mathrm{CAL}(\mathrm{mg}/l/\mathrm{div}) \cdot \mathrm{AREA\ (div \cdot sec)}}$$

Operating Limits and Warnings

Although this program leaves CO stored in memory, it erases all other stored patient data, including BSA.

Detailed User Instructions

This program calculates cardiac output from measurements taken directly from an indicator dilution curve. To obtain accurate results, it is important to measure the curve at frequent intervals. Generally, about ten points on the curve, equally spaced in time between onset and the 40%-of-peak point on the downslope, will be adequate. Choose a measurement time interval accordingly. Input the interval (Δt) and press [A].

Input the values measured from the curve (DC) and press [B] after each. The units of measurement are arbitrary; for example, divisions on the paper or volts, so long as the same units are used in inputting the calibration. The values are measured relative to the baseline, or starting level, of the curve. After each input entry, the display will indicate the number of points input.

As points on the downslope are input, the program compares each with the peak value. When the first point whose value is less than 65% of the peak value is found, it is stored for later use in the exponential projection as indicated by a minus sign preceding the displayed value representing the number of points input.

When a point having a value less than 45% of the peak value is input, the program automatically makes the exponential projection and displays the area under the curve, rather than the number of points entered.

At this time, input the CAL value. If indocyanine green dye is being used, it will generally be measured as milligrams of dye per liter of the patient's blood per division or unit of curve measurement. For other indicators, equivalent calibration factors must be determined.

Finally, input the dose of indicator given. For dye, this will usually be in mg. Press [D], and cardiac output in liters/min. will result. CO is stored in memory.

Program Description II

Sketch(es)

Sample Problem(s)

Δt = 1 sec.

DC = 5, 2, 45, 60, 50, 38, 28, 20 div.

CAL = 0.2 mg/l/div.

DOSE = 3 mg

Solution(s)

```
1[A] 5[B] 20[B] 45[B] 60[B] 50[B] 38[B] 28[B] 20[B] -------→  318.32 div/sec (area)
.2[C] 3[D] ---------------------------------------------→    2.82 l/min. (co)
```

Reference(s)

Yang, Sing San, et al, *From Cardiac Catheterization Data to Hemodynamic Parameters,*

F.A. Davis Co., Phil., 1972.

This program is a translation of the HP-65 Users' Library program #00205A submitted by Hewlett-Packard.

User Instructions

DYE CURVE CARDIAC OUTPUT

1 2

Δt DC → A CAL DOSE→CO

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input Δt	Δt(sec)	A	Δt(sec)
3	Repeat step 3 for each DC value measured from the curve	$DC_1 \ldots DC_{n-1}$(Div)	B	1 . . . (n−1)
	After the 45% or less DC value is input	DC n	B	area (Div•sec)
4	Input CAL	CAL(mg/l/Div)	C	CAL x area
5	Input DOSE and calculate CO	DOSE (mg)	D	CO(l/min)

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter Δt
002	CLRG	16-53	Clear registers
003	STO7	35 07	
004	RTN	24	
005	*LBLB	21 12	Enter dye curve values
006	DSZI	16 25 46	Count entries
007	ST+1	35-55 01	Integrate
008	RCL2	36 02	
009	X>Y?	16-34	New Peak?
010	GTO1	22 01	No
011	X⇄Y	-41	Yes
012	STO2	35 02	Save
013	X⇄Y	-41	
014	CF1	16 22 01	Clear 65% flag
015	*LBL1	21 01	
016	F1?	16 23 01	If flag 1 = Set
017	GTO2	22 02	then branch to LBL2
018	.	-62	
019	6	06	
020	5	05	
021	×	-35	
022	X>Y?	16-34	If past 65% then
023	GTO3	22 03	save values and
024	RCLI	36 46	branch to LBL 3,
025	CHS	-22	Else display count
026	RTN	24	
027	*LBL3	21 03	Do 65% test
028	X⇄Y	-41	
029	STO3	35 03	
030	RCLI	36 46	
031	STO4	35 04	
032	SF1	16 21 01	
033	RTN	24	
034	*LBL2	21 02	Do 45% test
035	.	-62	
036	4	04	
037	5	05	
038	×	-35	
039	X≤Y?	16-35	If not past 45%
040	GTO0	22 00	then RCL I & stop
041	R↓	-31	Else
042	STO2	35 02	
043	RCL4	36 04	
044	RCLI	36 46	
045	-	-45	
046	RCL3	36 03	
047	RCL2	36 02	
048	÷	-24	
049	LN	32	Compute exponential
050	÷	-24	area
051	.	-62	
052	5	05	
053	-	-45	
054	×	-35	
055	RCL1	36 01	
056	+	-55	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	RCL7	36 07	Compute total area
058	×	-35	
059	CF1	16 22 01	
060	STO2	35 02	
061	PRTX	-14	
062	RTN	24	
063	*LBLC	21 13	Enter CAL
064	RCL2	36 02	
065	×	-35	Compute CAL x AREA
066	STO2	35 02	
067	RTN	24	
068	*LBLD	21 14	Enter dye dose
069	RCL2	36 02	
070	÷	-24	
071	6	06	Compute CO
072	EEX	-23	
073	3	03	
074	×	-35	
075	INT	16 34	
076	STO7	35 07	
077	EEX	-23	
078	2	02	
079	÷	-24	
080	PRTX	-14	
081	RTN	24	
082	*LBL0	21 00	
083	RCLI	36 46	
084	RTN	24	
085	R/S	51	
100			
110			

FLAGS	
0	
1	65% flag
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	SD	Used	D65	-N65	Cleared	Cleared	Δt/100CO		Used

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Used

Program Description I

Program Title FICK CARDIAC OUTPUT

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program computes cardiac output, stroke volume, and cardiac index by the Fick method.

Equations Used:

$$CO(l/min) = \frac{VO_2 \text{ (ml/min STPD)} \cdot 100(\%)}{(C_aO_2 - C_vO_2)(vol.\%) \cdot 1000 \text{ (ml}/l)}$$

$$SV(ml/beat) = \frac{CO(l/min) \cdot 1000 \text{ (ml}/l)}{HR \text{ (beats/min)}}$$

$$CI(l/min/m^2) = \frac{CO(l/min)}{BSA(m^2)}$$

$$SI(ml/m^2) = \frac{SV(ml)}{BSA(m^2)}$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

C_aO_2 = 18 vol. %

C_vO_2 = 15 vol. %

VO_2 = 250 ml/min. STPD

BSA = $2m^2$

HR = 60 BPM

Solution(s)

18[A] 15[B] 250[C]	--------------------------	8.33 l/min. = CO
2[D]	--------------------------	4.17 l/min./m^2 = CI
60[E]	--------------------------	138.84 ml. = SV
[R/S]	--------------------------	-69.42 ml/m^2 = SI

Reference(s)

Yang, Sing San, et al, *From Cardiac Catheterization Data to Hemodynamic Parameters*, F.A. Davis Co., Phil., 1972.

This program is a translation of the HP-65 Users' Library program #00206A submitted by Hewlett-Packard.

User Instructions

FICK CARDIAC OUTPUT

1 RCL C_aO_2 | 2

C_aO_2 | C_vO_2 | VO_2→CO | BSA→CI | HR→SV

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	If C_aO_2 was stored previously *		f A	C_aO_2
3	Input C_aO_2	C_aO_2 (Vol.%)	A	C_vO_2 (if stored)
4	Input C_vO_2	C_vO_2 (Vol.%)	B	VO_2 (if stored)
5	Input VO_2 and calculate CO	VO_2 (ml/min)	C	CO (*l*/min)
6	If BSA was stored previously		R/S	BSA(m^2)
7	Input BSA and calculate CI	BSA(m^2)	D	CI(*l*/min/m^2)
8	Input heart rate and calculate SV and SI	HR(BPM)	E	SV(ml)
9	Display SI		R/S	SL(ml/m^2)

Detailed User Instructions:

* If the O_2 Saturation program has been run immediately previously, to calculate either arterial or venous O_2 content, C_aO_2 will be in the display register. To start, simply press [A]. If C_aO_2 is not in the display register, but has been previously stored, it may be recalled by pressing [f] [A] after entering the program card. Proceed as usual by inputting values or accepting recalled values for each parameter. Be sure VO_2 is in ml/min STPD.

To calculate cardiac index-assuming BSA has been previously stored-press [R/S] to recall BSA, then press [D]. Alternatively, enter BSA and press [D]. To calculate stroke volume enter heart rate and press [E]. Pressing [R/S] at this point will yield stroke index, with a minus sign, to avoid confusion with SV. Pressing [R/S] again returns to a display of SV.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Recall C_aO_2
002	RCL4	36 04	
003	R/S	51	
004	*LBLA	21 11	Enter C_aO_2
005	STO4	35 04	
006	RCL3	36 03	Recall C_vO_2
007	RTN	24	
008	*LBLB	21 12	Enter C_vO_2
009	STO3	35 03	
010	RCL2	36 02	Recall VO_2
011	RTN	24	
012	*LBLC	21 13	Enter VO_2
013	INT	16 34	
014	ENT↑	-21	
015	ENT↑	-21	
016	RCL2	36 02	Entangle with VCO_2 in R_2
017	FRC	16 44	
018	+	-55	
019	STO2	35 02	
020	CLX	-51	Compute CO
021	RCL4	36 04	
022	RCL3	36 03	
023	-	-45	
024	÷	-24	
025	1	01	
026	0	00	
027	÷	-24	
028	STO1	35 01	
029	EEX	-23	
030	2	02	
031	x	-35	
032	INT	16 34	
033	RCL7	36 07	
034	FRC	16 44	
035	+	-55	
036	STO7	35 07	
037	RCL1	36 01	
038	PRTX	-14	
039	RTN	24	
040	RCL7	36 07	
041	FRC	16 44	Untangle BSA
042	EEX	-23	
043	2	02	
044	x	-35	
045	R/S	51	
046	*LBLD	21 14	
047	STO8	35 08	
048	EEX	-23	Entangle BSA with CO in R7
049	2	02	
050	÷	-24	
051	RCL7	36 07	
052	INT	16 34	
053	+	-55	
054	STO7	35 07	
055	EEX	-23	
056	2	02	
057	÷	-24	
058	RCL8	36 08	
059	÷	-24	
060	PRTX	-14	
061	RTN	24	
062	*LBLE	21 15	Enter heart rate
063	RCL7	36 07	
064	X⇄Y	-41	Compute SV
065	÷	-24	
066	1	01	
067	0	00	
068	x	-35	
069	STO1	35 01	
070	PRTX	-14	
071	RTN	24	
072	*LBL1	21 01	Compute SI
073	RCL7	36 07	
074	FRC	16 44	
075	EEX	-23	
076	2	02	
077	x	-35	
078	÷	-24	
079	CHS	-22	
080	PRTX	-14	
081	R/S	51	
082	RCL1	36 01	Recall SV
083	PRTX	-14	
084	R/S	51	
085	GTO1	22 01	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	CO/SV	Used	C_vO_2	C_aO_2			Used	BSA	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title VALVE AREA

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program calculates aortic valve area and mitral valve area.

Equations Used:

$$\text{Valve Area (cm}^2\text{)} = \frac{\text{Mean Flow}}{0.0445\sqrt{\text{mean gradient}}}$$

where

$$\text{Mean Flow } (l/\text{sec}) = \frac{\text{CO } (l/\text{min.}) \cdot \text{R—R (sec)}}{\text{Valve Open Time (sec/beat)} \cdot 60 \text{ (sec/min.)}}$$

$$\text{Mitral Valve Area only} = \frac{\text{Valve Area}}{0.7}$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

DFP (mitral valve) = 0.55 sec

ΔP = 10, 12, 8, 6, 2 mmHg

R—R = 0.94 sec

CO = 5.73 *l*/min.

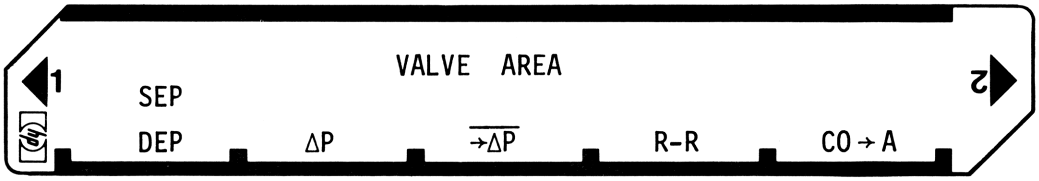
Solution(s)

```
[f] [A] --------> 1.00 (for mitral valve)
.55[A] 10[B] 12[B] 8[B] 6[B] 2[B] -----------> 5.0
                              [C] -----------> 7.60 mmHg,ΔP̄
.94[D] 5.73[E] ------------------------------> 1.90 cm², AREA
```

Reference(s) Gorlin, R.; Gorlin, S.G., "Hydraulic Formula for Calculation of the Area of the Stenotic Mitral Valve, Other Cardiac Valves, and Central Circulatory Shunts", *American Heart Journal,* Jan. 1957, VOL. 41, No. 1.

This program is a modification of the Users' Library program #00207A submitted by Hewlett-Packard.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	For regular calculations		f	A	0.00*
	For mitral valve calculations		f	A	1.00*
3.	Input SEP or DFP	seconds	A		SEP or DFP
4.	Repeat step 3 for each value of ΔP to be averaged	$\Delta P_1 .. P_n$ (mmHg)	B		1.. n
5.	Calculate $\overline{\Delta P}$		C		$\overline{\Delta P}$ (mmHg)
6.	Input R-R	R-R (sec)	D		CO(if stored)
7.	Input CO and calculate area	CO(1/min)	E		area(cm^2)
8.	If mitral valves		R/S		Mit.area (cm^2)
	DETAILED USER INSTRUCTIONS				
	Input the time duration, in seconds, of blood flow through the valve of interest; that is, the systolic ejection period (SEP) for outflow tract valves or the diastolic filing period (DFP) for A-V valves. Press [A].				
	This program permits averaging of a number of pressure gradients across the valve measured at different times while the valve is open. If the pressure gradient is to be measured at a number of different times, the time intervals should be equally spaced across the duration of the valve opening to obtain a true average. Simply input each value of pressure difference, (ΔP), in mmHg, and press [B] after each. The display will then show the number of input entries made. When all input entries have been made, press [C]. The average of all the ΔP values will be displayed ($\overline{\Delta P}$). If only one pressure gradient measurement is to be input, because averaging has been accomplished by some other means, simply input the value, press [B] and then press [C]. The input value will be displayed.				
	Input the R-R interval, in seconds, and press [D]. Cardiac output, if previously stored, will be recalled. If not, input it. Pressing [E] will display the valve area, in cm^2. A mitral area is indicated by a minus sign preceding the displayed value.				
	* If you don't get the desired display repeat [f] [A] until you do.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Toggle for regular
002	F0?	16 23 00	or mitral valve
003	GTO3	22 03	calculation
004	SF0	16 21 00	
005	1	01	
006	RTN	24	
007	*LBL3	21 03	
008	CF0	16 22 00	
009	0	00	
010	RTN	24	
011	*LBLA	21 11	Store T
012	STO9	35 09	
013	CF1	16 22 01	Clear Flag 1
014	RTN	24	
015	*LBLB	21 12	Enter ΔP
016	F1?	16 23 01	If first entry
017	GTO1	22 01	then initialize
018	STO1	35 01	Initialize averaging
019	SF1	16 21 01	
020	1	01	
021	STOI	35 46	
022	1	01	
023	RTN	24	
024	*LBL1	21 01	
025	ST+1	35-55 01	
026	ISZI	16 26 46	
027	RCLI	36 46	Display count
028	RTN	24	
029	*LBLC	21 13	Calculate $\overline{\Delta P}$
030	RCL1	36 01	
031	RCLI	36 46	
032	÷	-24	
033	CF1	16 22 01	
034	STO1	35 01	
035	PRTX	-14	
036	RTN	24	
037	*LBLD	21 14	Enter R-R
038	RCL9	36 09	Calculate S/M
039	X⇄Y	-41	
040	÷	-24	
041	6	06	
042	0	00	
043	×	-35	
044	STO8	35 08	
045	RCL7	36 07	Untangle CO
046	EEX	-23	
047	2	02	
048	÷	-24	
049	RTN	24	
050	*LBLE	21 15	Enter CO
051	ENT↑	-21	
052	ENT↑	-21	
053	EEX	-23	
054	2	02	
055	×	-35	Tangle CO with BSA
056	INT	16 34	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	RCL7	36 07	
058	FRC	16 44	
059	+	-55	
060	STO7	35 07	Recover CO
061	R↓	-31	
062	RCL8	36 08	Calculate area
063	÷	-24	
064	.	-62	
065	0	00	
066	4	04	
067	4	04	Hemodynamic k
068	5	05	
069	÷	-24	
070	RCL1	36 01	
071	√X	54	
072	÷	-24	
073	CF1	16 22 01	
074	F0?	16 23 00	
075	GTO2	22 02	
076	PRTX	-14	Display & store
077	STO8	35 08	area
078	RTN	24	
079	*LBL2	21 02	Calculate mitral
080	.	-62	area
081	7	07	
082	÷	-24	
083	CHS	-22	
084	PRTX	-14	
085	RTN	24	
086	R/S	51	
090			
100			
110			

FLAGS

0	Mitral?
1	ΔP Ave.
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	ΣΔP, $\overline{\Delta P}$						Used	S/M,A	T

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Used

Program Description I

Program Title ANATOMIC SHUNTS

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program calculates left-to-right and right-to-left shunts and displays them as a percentage. The program uses the method of allegations and can calculate bi-directional shunts.

Equations Used:

$$\text{R—L shunt (\%)} = \frac{(\text{L—PUL}) - (\text{L—SYST})}{(\text{L—PUL}) - (\text{R—SYST})} \cdot 100$$

$$\text{L—R shunt (\%)} = \frac{(\text{R—PUL}) - (\text{R—SYST})}{(\text{L—PUL}) - (\text{R—SYST})} \cdot 100$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

Calculate the left-to-right or right-to-left shunts for a patient having the following oxygen saturation values at the listed sites. Right atrium, 85%; pulmonary artery, 88%; left atrium, 95%; left ventricle, 93%.

Solution(s)

```
85[A] 88[B] 95[C] 93[D] [E] --------> 30.00% (L-R Shunt)
                        [E] --------> -20.00% (R-L) Shunt)
```

Reference(s)

Zimmerman, H.A., *Intravascular Catheterization*, Charles C. Thomas, Springfield, Ill., 1966.

This program is a translation of the HP-65 Users' Library program #00208A submitted by Hewlett-Packard

User Instructions

ANATOMIC SHUNTS

1 | 2

R-SYST | R-PUL | L-PUL | L-SYST | →SHUNTS

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input R—SYST	R—SYST(%)	A		R—SYST(%)
3	Input R—PUL	R—PUL(%)	B		R—PUL(%)
4	Input L—PUL	L—PUL(%)	C		L—PUL(%)
5	Input L—SYST	L—SYST(%)	D		L—SYST(%)
6	Calculate L—R		E		L—R(+ %)
7	Calculate R—L		E		R—L (−%)
	(Pressing [E] will display L—R and R—L alternately)				

DETAILED USER INSTRUCTIONS

The program assumes oxygen concentration values taken from four sites in the cardiovascular system. Since these sites may be various chambers in the heart or great vessels, they are labeled right systemic, right pulmonary, left pulmonary and left systemic. For example, suppose oxygen concentration values are known for the right atrium, pulmonary artery, left ventricle, and aorta; then the right systemic site would be the right atrium, the right pulmonary site would be the pulmonary artery, the left pulmonary site would be the left ventricle, and the left systemic site would be the aorta.

Input right systemic value, press [A]. Input right pulmonary value, press [B]. Input left pulmonary value, press [C]. Input left systemic value, press [D]. Note that it is possible to enter either oxygen contents or saturations, assuming hematocrit does not change during the sampling interval. Once all four sites have been input, press [E] to obtain the percent left-to-right shunt. If no shunt is calculated, 0 is displayed. Press [E] again to obtain the right-to-left shunt. Left-to-right shunts are reported as positive numbers, and right-to-left shunts as negative numbers. Each time [E] is pressed, either a left-to-right or right-to-left shunt will be displayed.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter R-syst
002	STO1	35 01	
003	STOI	35 46	Set toggle ≠ 1
004	RTN	24	
005	*LBLB	21 12	Enter R-Pul
006	STO2	35 02	
007	STOI	35 46	Set toggle ≠ 1
008	RTN	24	
009	*LBLC	21 13	Enter L-Pul
010	STO5	35 05	
011	STOI	35 46	Set toggle ≠ 1
012	RTN	24	
013	*LBLD	21 14	Enter L-syst
014	STO6	35 06	
015	STOI	35 46	Set toggle ≠ 1
016	RTN	24	
017	*LBLE	21 15	Compute shunts
018	DSZI	16 25 46	If I ≠ 1 then LBL 2
019	GTO2	22 02	otherwise compute
020	RCL5	36 05	R-L shunt
021	RCL6	36 06	
022	-	-45	
023	RCL5	36 05	
024	RCL1	36 01	
025	-	-45	
026	÷	-24	
027	EEX	-23	
028	2	02	
029	x	-35	
030	ENT↑	-21	
031	ABS	16 31	
032	X=Y?	16-33	
033	GTO1	22 01	
034	CLX	-51	
035	PRTX	-14	
036	RTN	24	
037	*LBL1	21 01	
038	CHS	-22	
039	PRTX	-14	
040	RTN	24	
041	*LBL2	21 02	Compute L-R shunt
042	1	01	
043	STOI	35 46	
044	RCL2	36 02	
045	RCL1	36 01	
046	-	-45	
047	RCL5	36 05	
048	RCL1	36 01	
049	-	-45	
050	÷	-24	
051	EEX	-23	
052	2	02	
053	x	-35	
054	ENT↑	-21	
055	ABS	16 31	
056	X=Y?	16-33	
057	GTO3	22 03	
058	CLX	-51	
059	PRTX	-14	
060	RTN	24	
061	*LBL3	21 03	
062	PRTX	-14	
063	RTN	24	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	R-syst	R-Pul			L-Pul	L-syst			

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Toggle

Program Description I

Program Title CONTRACTILITY

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program calculates the indices of left ventricular contractility based on pressure rise during isovolumetric contraction.

Equations Used:

P_N = most recently entered pressure (mmHg)

P_{N-1} = next previously entered pressure

Δt = time interval between pressure measurements (sec)

P_P = pressure at which dP/dt/P is calculated

$$\Delta P = P_N - P_{N-1}$$

$$\frac{dP}{dt} = \frac{\Delta P}{\Delta t} \text{ mmHg/sec}$$

$$P_P = \frac{P_N + P_{N-1}}{2}$$

$$dP/dt/P = \frac{dP/dt}{P_P} \sec^{-1}$$

P_M = P_P where dP/dt/P is a maximum

$$V_{MAX} = \frac{1}{30} \; \frac{(P_{P\,LAST} \cdot \text{MAX } dP/dt/P) - (P_M \cdot dP/dt/P_{LAST})}{P_{P\,LAST} - P_M}$$

Operating Limits and Warnings

Program Description II

Program Title Contractility

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

dP/dt is calculated as the difference between successive pressure inputs divided by the time interval Δt. The largest value found is stored as maximum dP/dt.

dP/dt/P is calculated for each pair of successive inputs, by first determining dP/dt as above, then dividing by the mean of the two pressures. The largest value found is stored as maximum dP/dt/P.

V_{MAX} is found in this program by a linear projection of the downslope of the dP/dt/P vs. P curve back to P = 0, and by dividing the resulting dP/dt/P by 30. The projection is based on the point at which the maximum dP/dt/P was found, and the last point input. The constant is controversial, values between about 28 and 32 having appeared in the literature. The value 30 is used in this program.

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

Find maximum dP/dt, maximum dP/dt/P and maximum ventricular contractility if Δt is 0.005 seconds and P_N is 10, 20, 40, 60, and 80 mmHg.

Solution(s)

```
.005[A] 10[B] 20[B] 40[B] 60[B] 80[B] [C] -------------> 4000 mmHg/sec(dP/dt)
                                      [D] ------------->  133.3 sec^-1(MAX.dP/dt/P)
                                      [E] ------------->    5.14 circ/sec (V_MAX)
```

Reference(s)

Yang, Sing San, et al, "From Cardiac Catheterization Data to Hemodynamic Parameters", F.A. Davis Co., Phil., 1972.

This program is a translation of the HP-65 Users' Library program #00209A submitted by Hewlett-Packard.

User Instructions

1	CONTRACTILITY				2
	Δt	PN	$\rightarrow$ MAX dP/dt	$\rightarrow$ MAX dP/dt/P	$\rightarrow V_{MAX}$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input Δt	Δt (seconds)	[A]	Δt(seconds)
3	Repeat step 3 for each P_n	$P_1 \ldots P_n$	[B]	dP/dt/P(sec^{-1})
4	Calculate maximum dP/dt		[C]	dP/dt(mmHg/sec)
5	Calculate maximum dP/dt/P		[D]	dP/dt/P(sec^{-1})
6	Calculate V_{max}		[E]	V_{max} (circ/sec)

DETAILED USER INSTRUCTIONS

The indices of left ventricular contractility calculated by this program are based on the pressure rise during isovolumetric contraction. Measurements, equally spaced in time, should be input for the isovolumetric phase only. Inputting values from the systolic ejection period can cause significant errors. Generally, between 5 and 10 pressure measurements should be input, and the time interval between measurements, Δt, chosen accordingly. Too few measurements will cause the maximum values to be missed. Too many will introduce excessive "noise" resulting in errors.

Input t in seconds, for example, .005. Press [A]. Input left ventricular pressure measurements in mmHg; press [B] after each. After each input except the first, dP/dt/P for the two most recent points will be displayed. When all points have been input, press [C], [D] and [E] in any order to obtain the corresponding results-maximum dP/dt, maximum dP/dt/P and V_{MAX}, maximum velocity of the contractile element at zero pressure in circumferences or lengths/sec.

If the contractility parameters are to be calculated using developed pressure, or any pressure reference other than zero, perform the subtraction before entering pressure values.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter Δt
002	STO6	35 06	
003	CLX	-51	
004	STO1	35 01	
005	STO3	35 03	
006	STO4	35 04	
007	STO5	35 05	
008	RCL6	36 06	
009	DSP3	-63 03	
010	RTN	24	
011	*LBLB	21 12	Enter P_N
012	DSP1	-63 01	
013	RCL1	36 01	
014	X⇄Y	-41	
015	STO1	35 01	
016	X⇄Y	-41	
017	0	00	
018	X=Y?	16-33	
019	RTN	24	
020	R↓	-31	
021	-	-45	
022	ENT↑	-21	
023	ENT↑	-21	Compute dP/dt
024	RCL6	36 06	
025	÷	-24	
026	RCL3	36 03	
027	X⇄Y	-41	
028	X>Y?	16-34	
029	STO3	35 03	Save max dP/dt
030	RCL1	36 01	
031	R↑	16-31	
032	2	02	
033	÷	-24	
034	-	-45	
035	STO8	35 08	Save P_p
036	÷	-24	
037	STO2	35 02	
038	RCL4	36 04	
039	X⇄Y	-41	
040	X≤Y?	16-35	
041	RTN	24	
042	STO4	35 04	
043	LSTX	16-63	
044	STO5	35 05	
045	R↓	-31	
046	RTN	24	
047	*LBLC	21 13	Display max dP/dt
048	RCL3	36 03	
049	DSP0	-63 00	
050	PRTX	-14	
051	RTN	24	
052	*LBLD	21 14	Display max dP/dt/P
053	RCL4	36 04	
054	DSP1	-63 01	
055	PRTX	-14	
056	RTN	24	
057	*LBLE	21 15	Compute V_{max}
058	DSP2	-63 02	
059	RCL8	36 08	
060	RCL4	36 04	
061	×	-35	
062	RCL5	36 05	
063	RCL2	36 02	
064	×	-35	
065	-	-45	
066	RCL8	36 08	
067	RCL5	36 05	
068	-	-45	
069	X=0?	16-43	
070	GTO1	22 01	
071	÷	-24	
072	3	03	
073	0	00	
074	÷	-24	
075	PRTX	-14	
076	RTN	24	
077	*LBL1	21 01	
078	PRTX	-14	
079	RTN	24	
080	R/S	51	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1 P_N	2 dP/dt/P	3 MAX dP/dt	4 MAX dP/dt/P	5 P_n	6 Δt	7	8 P_p	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title STROKE WORK

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables, etc.

This program calculates stroke work (SW) and stroke work index (SWI). For stroke work based on systolic minus end-diastolic pressure, perform subtraction before data input.

Equations Used:

$$SW(gm \cdot m) = \frac{13.6 \cdot P(mmHg) \cdot CO(l/min) \cdot R{-}R(sec)}{60\ (sec/min)}$$

$$SWI(gm \cdot m/m^2) = \frac{SW(gm \cdot m)}{BSA(m^2)}$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

P_{sys} = 100, 110 mmHg

R—R = 1 sec

CO = 5 l/min.

BSA = 2 m^2

Solution(s)

```
100[A] 110[A] [B] ---------------------> 105 mmHg(P̄)
       1[C] 5[D] ---------------------> 119.0 gm•m(SW)
            2[E] --------------------->  59.50 gm•m/m2(SWI)
```

Reference(s)

Yang, Sing San, et al, "From Cardiac Catheterization Data to Hemodynamic Parameters", F.A. Davis Co., Phil., 1972.

This program is a translation of the HP-65 Users' Library program #00210A submitted by Hewlett-Packard.

User Instructions

STROKE WORK

1 2

PSYS	→P	R-R	CO→SW	BSA→SWI

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Repeat step 2 for each value of P_{sys}(mmHg)	$P_{sys_1} \ldots P_{sys_n}$	A		1 . . . n
3	Calculate $\overline{P}$		B		$\overline{P}$ (mmHg)
4	Input R–R	R–R(sec)	C		CO (if stored)
5	Input CO and calculate stroke work	CO(*l*/min)	D		SW(gm •m)
6	If BSA was previously stored		R/S		BSA(m^2)
7	Input BSA and calculate SWI	BSA(m^2)	E		SWI(gm•m/m^2)

DETAILED USER INSTRUCTIONS

The mean systolic pressure, $\overline{P}$, is required for stroke work calculation. The program will average pressures measured at equal time intervals through systole to obtain the mean. Input the pressure measurements and press [A] after each. The number of inputs will be displayed. When all inputs have been made, press [B] to obtain the mean systolic pressure.

If averaging is accomplished by other means, and only a single value is input, press [A] and then [B] If an error is made in the pressure inputs, restart program by pressing [B] and rekey the input data.

Input the R-R interval in seconds and press [C]. If cardiac output has been previously stored in memory, it will be recalled; if not, input it now. Press [D], and stroke work in gm•m will be displayed. To obtain stroke work index divide by BSA. If BSA has been stored press [R/S] to recall it. Otherwise, input BSA. Press [E]. and stroke work index will be displayed in gm•m/m^2.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter P_{sys}
002	F1?	16 23 01	
003	GTO1	22 01	If first entry then
004	STO1	35 01	INT else integrate
005	1	01	Initialize
006	CHS	-22	
007	STOI	35 46	
008	SF1	16 21 01	
009	1	01	
010	RTN	24	
011	*LBL1	21 01	
012	ST+1	35-55 01	
013	DSZI	16 25 46	
014	RCLI	36 46	
015	CHS	-22	Display count, N
016	RTN	24	Compute $\overline{P}$
017	*LBLB	21 12	
018	RCL1	36 01	
019	RCLI	36 46	
020	CHS	-22	
021	÷	-24	
022	STO1	35 01	
023	PRTX	-14	
024	CF1	16 22 01	
025	RTN	24	
026	*LBLC	21 13	Enter R-R
027	STO8	35 08	
028	RCL7	36 07	Untangle CO
029	EEX	-23	
030	2	02	
031	÷	-24	
032	RTN	24	
033	*LBLD	21 14	Enter CO
034	ENT↑	-21	
035	ENT↑	-21	
036	EEX	-23	
037	2	02	
038	×	-35	
039	FRC	16 44	
040	RCL7	36 07	Tangle CO with BSA
041	FRC	16 44	
042	+	-55	
043	STO7	35 07	
044	R↓	-31	Compute stroke work
045	RCL8	36 08	
046	×	-35	
047	6	06	
048	0	00	
049	÷	-24	
050	RCL1	36 01	
051	×	-35	
052	1	01	
053	3	03	
054	.	-62	
055	6	06	
056	×	-35	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	STO9	35 09	
058	PRTX	-14	
059	CF1	16 22 01	
060	RTN	24	
061	RCL7	36 07	Untangle BSA
062	FRC	16 44	
063	EEX	-23	
064	2	02	
065	×	-35	
066	R/S	51	
067	*LBLE	21 15	Enter BSA
068	STO1	35 01	
069	EEX	-23	Tangle BSA with CO
070	2	02	
071	÷	-24	
072	RCL7	36 07	
073	INT	16 34	
074	+	-55	
075	STO7	35 07	Compute SWI
076	RCL9	36 09	
077	RCL1	36 01	
078	÷	-24	
079	PRTX	-14	
080	RTN	24	
081	R/S	51	

FLAGS

Flag	
0	
1	P AVER.
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	ΣP, $\overline{P}$, BSA						Used	R-R	SW

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Used

Program Description I

Program Title Ejection Fraction - Ejected Volume - Cardiac Output

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Given the following information: LED, LES, AED, AES, f and Heart Rate (HR).

$$\text{Ejection Fraction (in percent)} = \left[1 - \frac{AES^2}{AED^2} \times \frac{LED}{LES}\right] \times 100$$

$$\text{Ejected Volume (in cc/stroke)} = (\text{Ejection Fraction}) \times \left(\frac{8\ AED^2}{3\pi f^3\ LED}\right) \div 100$$

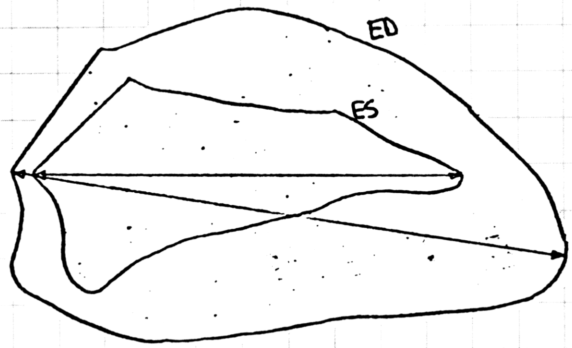
$$\text{Cardiac Output (in l/min.)} = (\text{Ejected Volume}) \times (\text{Heart Rate}) \div 1000$$

Operating Limits and Warnings

Calulate ejection fraction before ejected volume, and ejected volume before cardiac output.

Program Description II

Sketch(es)



Sample Problem(s)

Find the Ejection Fraction, Ejected Volume, and Cardiac Output from the following data.

LED = 12.6 cm

LES = 9.7 cm

AED = 68.5 cm^2

AES = 23.2 cm^2

f = 1.54:1

Heart Rate = 72 bpm

Solution(s)

```
12.6 [ENT↑] 9.7[A] 68.5[ENT↑] 23.2[B]
 1.54[ENT↑] 72[f] [A] [C] ------------->85.10% (Ejection Fraction)
                      [D] ------------->73.65% (Ejected Volume)
                      [E] -------------> 5.30 l/min. (CO)
```

Reference(s)

Doge, HT. Sandler, H. Ballew et al. "The use of biplane angio-cardiography for the measurement of left ventricular volume in man." American Heart J.60: 762-776 1960 Greene, D.G. Carlisle, R. Grant, C. Circulation 35: 61-69 1967.

This program is a modification of the HP-65 Users' Library program #01190A submitted by Norman R. McLarin.

User Instructions

EJECTION FRACTION - EJECTED
VOLUME-CARDIAC OUTPUT

1 | f ↑ Rate
LED ↑ LES | AED ↑ AES | E F | E V | C O | 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Enter length end diastole and	LED,cm	ENT↑		
	length end systole	LES, cm	A		LED,cm
3.	Enter area end diastole and	AED, cm^2	ENT↑		
	area end systole	AES,cm^2	B		AED,cm^2
4.	Enter correction factor f and	f	ENT↑		
	heart rate	HR,BPM	f	A	f
5.	Calculate ejection fraction		C		E.F,%
6.	Calculate ejected volume		D		E.V.,cc/stroke
7.	Calculate cardiac output		E		C.O.,l/min.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Store LED & LES
002	STO2	35 02	
003	R↓	-31	
004	STO1	35 01	
005	RTN	24	
006	*LBLB	21 12	Store AED & AES
007	STO4	35 04	
008	R↓	-31	
009	STO3	35 03	
010	RTN	24	
011	*LBLa	21 16 11	Store corr. factor
012	STO6	35 06	& heart rate
013	R↓	-31	
014	STO5	35 05	
015	RTN	24	
016	*LBLC	21 13	Calculate ejection
017	RCL4	36 04	fract.
018	X²	53	AES^2
019	RCL1	36 01	
020	×	-35	
021	RCL2	36 02	
022	÷	-24	
023	STO7	35 07	
024	RCL3	36 03	
025	X²	53	AED^2
026	STO8	35 08	
027	RCL7	36 07	
028	X⇄Y	-41	
029	÷	-24	
030	CHS	-22	
031	1	01	
032	+	-55	
033	STO7	35 07	
034	RCL8	36 08	
035	×	-35	
036	STO8	35 08	
037	RCL7	36 07	
038	EEX	-23	Calc. %
039	2	02	
040	×	-35	
041	PRTX	-14	
042	STO7	35 07	Store EF
043	RTN	24	
044	*LBLD	21 14	Calculate ejected
045	RCL8	36 08	volume
046	8	08	RCL EF' x AED^2
047	×	-35	
048	3	03	
049	÷	-24	
050	Pi	16-24	
051	÷	-24	
052	RCL1	36 01	Get LED
053	÷	-24	
054	STO8	35 08	
055	RCL5	36 05	f
056	X²	53	
057	RCL5	36 05	f^3
058	×	-35	
059	RCL8	36 08	
060	X⇄Y	-41	
061	÷	-24	
062	PRTX	-14	Store ejected vol.
063	STO8	35 08	
064	RTN	24	
065	*LBLE	21 15	Calculate cardiac
066	RCL8	36 08	output
067	RCL6	36 06	
068	×	-35	
069	EEX	-23	
070	3	03	
071	÷	-24	
072	PRTX	-14	Store cardiac
073	STO9	35 09	output
074	RTN	24	
075	R/S	51	
080			
090			
100			
110			

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	LED	LES	AED	AES	f	HRT RATE	EJECT. FRACT.	EJECT. VOL.	CO
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Calculation of Left Ventricular Functions from Angiograpic Data

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Program allows calculation of left ventricular functions by both single and biplane methods: Functions calculated are:

End systolic colume (ESV), either single or biplane

End diastolic volume (EDV), either single or biplane

Velocity of circumf. fiber shortening (V_{cf})

Stroke volume (SV)

Stroke index (SI)

Systolic ejection fraction as % (SEF %)

Heart Rate

Cardiac index (CI)

Average systolic & diastolic diameters are also calculated

Equations:

$$\text{Biplane CV} = \frac{8}{3\pi} \frac{(A_{RAO})(CF_{RAO})(A_{LAO})}{L_{RAO}}$$

$$\text{Single plane CV} = \frac{8}{3\pi} \frac{(A_{RAO})^2 \times (CF_{RAO})^{3/2}}{L_{RAO}}$$

True ventricular volumes: Biplane TV = 0.895CV-5.113 ml
(where CV = Calc. volume) Single TV = 0.81CV+1.9 ml

SEE: Vogel, Swenson & Elings,"Simple Method for Calculating Left Ventricular Function Etc.," Catheterization & Cardiovascular Diagnosis, 2:199-210 (1976) for complete description of calculations.

OPERATING LIMITS AND WARNINGS When using this program on HP-67 be sure pause display of results has finished blinking before pressing key for next calculation. Otherwise erroneous results may occur.

Program Description II

Sketch(es)

Sample Problem(s) A patient's body surface area is 1.75m^2. Angiographic measurements give the following data: Number of frames: 19; number of frames per beat: 43; correction factors: 1.39(RAO), 0.83(LAO)

Systolic Function

	RAO	LAO
AREA	35.4	32.4
AXIS	9.1	7.7

Diastolic Function

	RAO	LAO
AREA	52.1	54.7
AXIS	10.5	10.0

Calculate left ventricular functions by both the single plane & biplane methods.

Solution(s) Single plane: 1.75 [ENT↑] 19[ENT↑] 35.4[ENT↑] 9.1[f] [E]
1.39 [ENT↑] 43[ENT↑] 52.1[ENT↑] 10.5[R/S]

[A] ----->157.06, ESV	[f] [C] ------->83.72,Heart Rate	[f][B]--->196.66, EDV
89.75,ESV/m^2	6.51,CI	112.38,EDV/m^2
[B] ----->293.18,EDV	Biplane:	[f][D]---> 5.36,SYS DIA.
167.53,EDV/m^2	.83[ENT↑] 32.4[ENT↑]	6.90,DIAS DIA.
[C] -----> 0.68, V_{cf}	7.7[f][A] 54.7[ENT↑]	[D] ----->108.07,SV
[D] ----->136.12,SV	10[R/S] -------> 88.59,ESV	61.76,SI
77.78,SI	50.62,ESV/m^2	[E] -----> 54.95,SEF%
[E] -----> 46.43,SEF%		[C] -----> 0.70 V_{cf}

Reference(s) This program is a modification of the HP-65 Users' Library program #05352A submitted by J.H.K. Vogel.

Vogel, Swenson & Elings, "A Simple Method for Calculating Left Ventricular Functions from Angiographic Data, Etc", Catheterization and Cardio Vascular Diagnosis, 2: 199-210, (1976).

User Instructions

LEFT VENTRICULAR FUNCTIONS

1	ESV_{Bi}	EDV_{Bi}	RATE, CI	AVE.DIA.	INITIAL.	2
	ESV	EDV	V_{cf}	SV,SI	SEF%	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load sides 1 & 2				
2.	Enter data: Body surface area	BSA,m^2	ENT↑		
	Number of frames	#	ENT↑		
	Systolic area, RAO	SA,cm^2	ENT↑		
	Systolic length, RAO	SL,cm	f	E	
	Correction factor, RAO	CF_{RAO}	ENT↑		
	Number of frames/beat	#	ENT↑		
	Diastolic area, RAO	DA,cm^2	ENT↑		
	Diastolic Length, RAO	DL,cm	R/S		
	SINGLE PLANE CALCULATIONS:				
3.	Calculate: End systolic VOL_0,(ESV)		A		ESV,ml
	and ESV index				ESV/m^2
4.	Calculate: End diastolic Vol., (EDV)		B		EDV,ml
	and EDV				EDV/m^2
5.	Calculate: Velocity of circumferential fiber				
	shortening, V_{cf}		C		V_{cf}, $\frac{circ}{sec}$
6.	Calculate: Stroke volume and		D		SV, ml
	stroke index				SI, ml/m^2
7.	Calculate: Systolic ejection fraction (%)		E		SEF%
8.	Calculate: Heart rate and cardiac index		f	C	Heart Rate
	BIPLANE CALCULATIONS:				CI,l/min.
9.	Enter data & calculate ESV & ESV index				
	Correction factor, LAO	CF_{LAO}	ENT↑		
	Systolic area, LAO	SA,cm^2	ENT↑		
	Systolic length, LAO	SL,cm	f	A	
	Diastolic area, LAO	DA,cm^2	ENT↑		
	Diastolic length, LAO	DL,cm	R/S		ESV,ESV/m^2
10.	Calculate: EDV & EDV index		f	B	EDV,EDV/m^2
11.	Calculate: Average systolic & diastolic DIA.		f	D	$\overline{Sys.}$,$\overline{Dias.}$
12.	Calculate: Stroke volume & stroke index		D		SV,SI
13.	Calculate: Systolic ejection fraction (%)		E		SEF%
14.	Calculate: Velocity of circumf. fiber shortening		C		V_{cf}

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLe	21 16 15	Initialize & store data
002	GSB1	23 01	
003	STO2	35 02	
004	R/S	51	
005	P⇄S	16-51	
006	GSB1	23 01	
007	STO0	35 00	
008	P⇄S	16-51	
009	STO0	35 00	
010	RTN	24	
011	*LBL1	21 01	
012	CLRG	16-53	
013	STO6	35 06	
014	R↓	-31	
015	STO4	35 04	
016	R↓	-31	
017	STO3	35 03	
018	R↓	-31	
019	RTN	24	
020	*LBLA	21 11	Calculate ESV, single plane
021	GSB9	23 09	
022	STOA	35 11	
023	PRTX	-14	
024	GTO8	22 08	ESV/m^2
025	*LBLB	21 12	Calculate EDV, single plane
026	P⇄S	16-51	
027	GSB9	23 09	
028	P⇄S	16-51	
029	STOB	35 12	
030	PRTX	-14	
031	GTO8	22 08	EDV/m^2
032	*LBL9	21 09	Calculate ventricular volumes single plane
033	RCL4	36 04	
034	RCL0	36 00	
035	√X	54	
036	×	-35	
037	4	04	
038	×	-35	
039	Pi	16-24	
040	÷	-24	
041	RCL6	36 06	
042	÷	-24	
043	STO8	35 08	
044	2	02	
045	×	-35	
046	3	03	
047	÷	-24	
048	RCL4	36 04	
049	×	-35	
050	RCL0	36 00	
051	×	-35	
052	.	-62	
053	8	08	
054	1	01	
055	×	-35	
056	1	01	
057	.	-62	
058	9	09	
059	+	-55	
060	RTN	24	
061	*LBL8	21 08	Divide by BSA
062	RCL2	36 02	
063	÷	-24	
064	P⇄S	16-51	
065	STO2	35 02	
066	P⇄S	16-51	
067	PRTX	-14	
068	SPC	16-11	
069	RTN	24	
070	*LBLC	21 13	Calculate V_{cf}
071	RCL8	36 08	
072	P⇄S	16-51	
073	RCL8	36 08	
074	P⇄S	16-51	
075	-	-45	
076	CHS	-22	
077	LSTX	16-63	
078	÷	-24	
079	RCL3	36 03	
080	÷	-24	
081	6	06	
082	0	00	
083	×	-35	
084	STOC	35 13	
085	PRTX	-14	
086	SPC	16-11	
087	RTN	24	
088	*LBLD	21 14	Calculate SV
089	RCLB	36 12	
090	RCLA	36 11	
091	-	-45	
092	STOD	35 14	
093	PRTX	-14	
094	GTO8	22 08	Calculate SI
095	P⇄S	16-51	
096	STO2	35 02	
097	P⇄S	16-51	
098	PRTX	-14	
099	SPC	16-11	
100	RTN	24	
101	*LBLE	21 15	Calculate SEF%
102	RCLD	36 14	
103	RCLB	36 12	
104	÷	-24	
105	EEX	-23	
106	2	02	
107	×	-35	
108	PRTX	-14	
109	STOE	35 15	
110	SPC	16-11	
111	RTN	24	
112	*LBLc	21 16 13	

REGISTERS

0 CF_{RAO}	1 CF_{LAO}	2 BSA	3 #Frames	4 SA_{RAO}	5 SA_{RAO}	6 SL_{RAO}	7 SL_{LAO}	8 ~~S DIA~~ S.DIA	9 $S.DIA_{RAO}$
S0 CF_{RAO}	S1 CF_{LAO}	S2 SI	S3 FR/BEAT	S4 DA_{RAO}	S5 DA_{RAO}	S6 DL_{RAO}	S7 DL_{LAO}	S8 ~~D DIA~~ D.DIA	S9 $D.DIA_{RAO}$

A ESV	B EDV	C V_{cf}	D SV	E SEF%	I

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	P⇄S	16-51	Calculate heart rate
114	RCL3	36 03	
115	6	06	
116	0	00	
117	X²	53	
118	÷	-24	
119	1/X	52	
120	PRTX	-14	
121	RCL2	36 02	Cardiac index
122	×	-35	
123	P⇄S	16-51	
124	EEX	-23	
125	3	03	
126	÷	-24	
127	PRTX	-14	
128	SPC	16-11	
129	RTN	24	
130	*LBLa	21 16 11	Store biplane data
131	STO7	35 07	
132	R↓	-31	
133	STO5	35 05	
134	R↓	-31	
135	STO1	35 01	
136	P⇄S	16-51	
137	STO1	35 01	
138	R/S	51	
139	STO7	35 07	
140	R↓	-31	
141	STO5	35 05	
142	P⇄S	16-51	
143	GSB7	23 07	Calculate ESV, biplane
144	STOA	35 11	
145	PRTX	-14	
146	GTO8	22 08	ESV/m^2
147	*LBLb	21 16 12	EDV,biplane
148	P⇄S	16-51	
149	GSB7	23 07	
150	P⇄S	16-51	
151	STOB	35 12	
152	PRTX	-14	
153	GTO8	22 08	EDV/m^2
154	*LBL7	21 07	Calculation of ventricular volumes by biplane method
155	4	04	
156	Pi	16-24	
157	÷	-24	
158	RCL4	36 04	
159	×	-35	
160	RCL0	36 00	
161	√X	54	
162	×	-35	
163	RCL6	36 06	
164	÷	-24	
165	STO9	35 09	
166	2	02	
167	×	-35	

STEP	KEY ENTRY	KEY CODE	COMMENTS
168	3	03	
169	÷	-24	
170	RCL5	36 05	
171	×	-35	
172	RCL1	36 01	
173	×	-35	
174	.	-62	
175	8	08	
176	9	09	
177	5	05	
178	×	-35	
179	5	05	
180	.	-62	
181	1	01	
182	1	01	
183	3	03	
184	-	-45	
185	RTN	24	Ave. dia. by biplane method
186	*LBLd	21 16 14	
187	GSB6	23 06	
188	P⇄S	16-51	
189	GSB6	23 06	
190	P⇄S	16-51	
191	SPC	16-11	
192	RTN	24	
193	*LBL6	21 06	
194	4	04	
195	Pi	16-24	
196	÷	-24	
197	RCL5	36 05	
198	×	-35	
199	RCL1	36 01	
200	√X	54	
201	×	-35	
202	RCL7	36 07	
203	÷	-24	
204	RCL9	36 09	
205	+	-55	
206	2	02	
207	÷	-24	
208	PRTX	-14	
209	STO8	35 08	
210	RTN	24	
211	R/S	51	
220			

LABELS

A ESV sing	B EDV sing	C V_{cf}	D SV	E SEF%
a ESV bi	b EDV bi	c HRT RT.CI	d AVE.DIA.	e Initialize
0	1 Store	2	3	4
5	6 Calc.AVE.	7 ESV&EDV Bi	8 X/BSA	9 Used

FLAGS

0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☐	GRAD	☐	SCI	☐
2	☐	☐	RAD	☐	ENG	☐
3	☐	☐			n	2

Program Description I

Program Title Impedance Cardiac Output, Systemic and Pulmonary Resistance

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

$$\Delta V = \frac{\rho L^2 (dZ/dt)\min}{Z_0^2}$$

$$CO = \frac{V \cdot HR}{1000}$$

$$CI = \frac{CO}{BSA}$$

$$\overline{P} = \frac{P_s - P_d}{3} + P_d$$

$$R_t = \frac{\overline{P}}{CO} \quad (\text{or } \frac{\overline{P}}{CI}) \text{ units}$$

$$R_t = (\text{units}) \cdot 80 = R_t \text{ (dyne sec cm}^{-5})$$

$$R_v = \frac{\overline{P} - P_{Atr}}{CO} \quad (\text{or } \frac{\overline{P} - P_{Atr}}{CI}) \text{ units}$$

$$R_v \quad (\text{units}) \cdot 80 = R_v \text{ (dyne sec cm}^{-5})$$

ρ = 135
L = mean dist. bet inner electrode (cm)
Z_o= mean impedance bet electrode (ohm)
(dZ/dt)min = minimum dz/dt (ohm/cm)
T = ventricular ejection time (sec)
ΔV= stroke vol. (ml)
HR= heart rate (beats/min)
CO= cardiac output (L/min)
CI= cardiac index (L/min)
BSA= body surface area (m^2)
P_s= systolic pressure (mmHg)
P_d= diastolic pressure (mmHg)
$\overline{P}$ = mean arterial pressure (mmHg)
P_{Atr}= atrial pressure (mmHg)
R_t= total systemic (or pulmonary) resistance
R_v= systemic (or pulmonary) vascular resistance

Operating Limits and Warnings

For CI or CI derived values BSA must be entered, either keyed [f][D] in and saved in STO 1 or calulated by HP program BODY SURFACE AREA FOR CARDIO PULMONARY (saved automatically). Error display usually indicates BSA has not been stored.

Program Description II

Sketch(es)

Sample Problem(s) Find 1) stroke volume, cardiac output, cardiac index, 2) mean arterial pressure, total systemic resistance (units dyne sec cm^{-5}), systemic vascular resistance (units, dyne sec cm^{-5}), 3) total pulmonary resistance, pulmonary vascular resistance

Height 5'7" Weight 69.4 kg BSA 1.81 m^2

dZ/dt = .81
T = .23
L = 28.5
Z_0 = 20.2
Heart Rate = 103

BP systemic = 120/80 mmHg
CVP ($\overline{P}_{RA}$) = 15 mmHg
BP pulmonary= 44/24 mmHg
$\overline{P}_{LA}$ = 13 mmHg

Solution(s) [f][E] ----->1.00 [f] [E] ---> 0.00 (set for calc by CO)

1) 1.81 [f][D] .81[ENT↑] .23[A] 28.5[B] 20.2[C] ---->50.06ml,SV;103[D]--->5.16l/min;CO
2.85l/min;CI

2) 120[ENT↑] 80[f] [A] ------> 93.33mmHg, mean press
18.10 units, total sys. resist.
[R/S]------>1447.96dyne-sec-cm^{-5},sys. resist.
15[f] [B] ------> 15.19 units, sys. vasc. resist.
[R/S]------>1215.25 dyne-sec-cm^{-5},vasc. resist.

3) 44[ENT↑] 24[f][A] --------> 30.67mmHg, mean pulm. press.
5.95 units, total pulm. resist.
13[f][B] --------> 3.43 units, pulm. vasc. resist.

Reference(s)
Pomerantz, M., Delgado, F., and Eiseman, B.: Unsuspected Depressed Cardiac Output Following Blunt Thoracic or Abdominal Trauma. Surg. 70:865-871, 1971. Blackwell Scientific Publications: Medical and Surgical Cardiology, pp. 120-121, Wm. Cowles & Sons, Ltd., London, 1969. Kubicek, William: The Minnesota Impedance Cardiograph; Theory and Application. Biomed. Eng., Vol. 9, No.9, Sept.1974,pg.410-421.

User Instructions

IMP. CARD OUTPUT, SYS & PULM. RESIST.

1 TOTAL RES. VASC RES. BSA CO or CI 2

dZ/dt ↑ T L Z_0 → SV RATE→ CO

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load side 1				
2.	Set toggle for resistance calculation:				
	By CO		f	E	0.00*
	By CI		f	E	1.00*
3.	Store body surface area	BSA,m^2	f	D	BSA,m^2
4.	Calculate stroke volume:				
	Input dZ/dt		ENT↑		
	Input ventricular ejection time	T,sec	A		0 or Prev. L
	Input mean dist. between electrodes	L,cm	B		L
	Input mean impedance between electrodes	Z_0,ohm	C		Stroke,Vol,ml
5.	Input heart rate & calculate cardiac output & cardiac index	Ht.R.,	D		CO,l/min.
					CI,l/min.
6.	Optional: for new cardiac output go to 4				
7.	Calculate total systemic resistance				
	Input systolic press (systemic)	BP.,mmHg	ENT↑		
	Input diastolic press (systemic)	BP.,mmHg	f	A	Mean P,mmHg
					Tot. Resist.
7'	Optional: for total resistance in dyne-sec-cm^{-5}		R/S		Tot. Resist.
8.	Calculate vascular resistance:				
	Input atrial pressure	P_{ATR},mmHg	f	B	Vasc.Resist.
8'	Optional: for vascular resistance in dyne-sec-cm^{-5}		R/S		Vasc. Resist.
9.	To calculate pulmonary resistances repeat steps 7 & 8 using pulmonary blood pressure				
	*If you don't get desired output press [f][E] again, until you do.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLd	21 16 14	
002	STO1	35 01	Store BSA
003	RTN	24	
004	*LBLA	21 11	
005	x	-35	aZ/dt x T
006	STO9	35 09	
007	RCL2	36 02	
008	RTN	24	
009	*LBLB	21 12	Input L
010	STO2	35 02	
011	ENT↑	-21	
012	x	-35	
013	1	01	
014	3	03	
015	5	05	p
016	x	-35	
017	STO8	35 08	
018	RCL2	36 02	
019	RTN	24	
020	*LBLC	21 13	Input Z_0 and
021	STO3	35 03	calculate stroke
022	ENT↑	-21	vol.
023	x	-35	
024	1/X	52	
025	RCL9	36 09	
026	RCL8	36 08	
027	x	-35	
028	x	-35	
029	PRTX	-14	SV
030	RTN	24	
031	*LBLD	21 14	Input heart rate
032	x	-35	& calculate CO & CI
033	EEX	-23	
034	3	03	
035	÷	-24	
036	STO4	35 04	
037	PRTX	-14	CO
038	RCL1	36 01	
039	÷	-24	
040	PRTX	-14	CI
041	RTN	24	
042	*LBLa	21 16 11	Calculate mean
043	STO7	35 07	press.
044	-	-45	
045	3	03	
046	÷	-24	
047	RCL7	36 07	
048	+	-55	
049	PRTX	-14	$\overline{P}$
050	*LBL2	21 02	Calculate resist.
051	STO6	35 06	
052	RCL4	36 04	
053	÷	-24	By CI
054	F0?	16 23 00	
055	GSB0	23 00	Yes
056	PRTX	-14	No, print resist.

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	R/S	51	Resistance in
058	8	08	$\frac{\text{Dyne-sec.}}{\text{cm}^5}$
059	0	00	
060	x	-35	
061	PRTX	-14	
062	RTN	24	
063	*LBLb	21 16 12	Input atrial pressure
064	CHS	-22	& calculate vascular
065	RCL6	36 06	resist.
066	+	-55	
067	GTO2	22 02	
068	*LBL0	21 00	Divide by BSA
069	RCL1	36 01	
070	÷	-24	
071	RTN	24	
072	*LBLe	21 16 15	Toggle for calc by
073	F0?	16 23 00	CO or CI
074	GTO1	22 01	
075	SF0	16 21 00	Set F0, DSP 1.00 &
076	1	01	calculate by CO
077	RTN	24	
078	*LBL1	21 01	
079	CF0	16 22 00	Clear f0 DSP 0.00
080	0	00	& calc. by CO
081	RTN	24	
082	R/S	51	
090			
100			
110			

FLAGS	
0	CO or CI
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	BSA	L	Z_0	CO	CI	Used	Used	Used	Used

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title BASIC EKG DETERMINATIONS

Contributor's Name Hewlett - Packard Company

Address 1000 N.E. Circle Boulevard

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Given the magnitudes of both the positive and negative deflections of leads I and III (in millimeters of a graduated EKG)

displayed is the predicted magnitude (pos. minus neg. deflections) according to Einthoven's Law: Lead II = Lead I + Lead III of Lead II

computed is the mean electric axis of the heart
axis rectangular coordinates = Lead I(.5774) + Lead III(1.1547)
axis angular coordinates = conversion to polar coordinates

Given either the heart rate or the R-R interval, the other is computed

$$\text{heart rate} = \frac{60}{\text{R-R interval}}$$

computed is the predicted normal Q-T interval for that rate

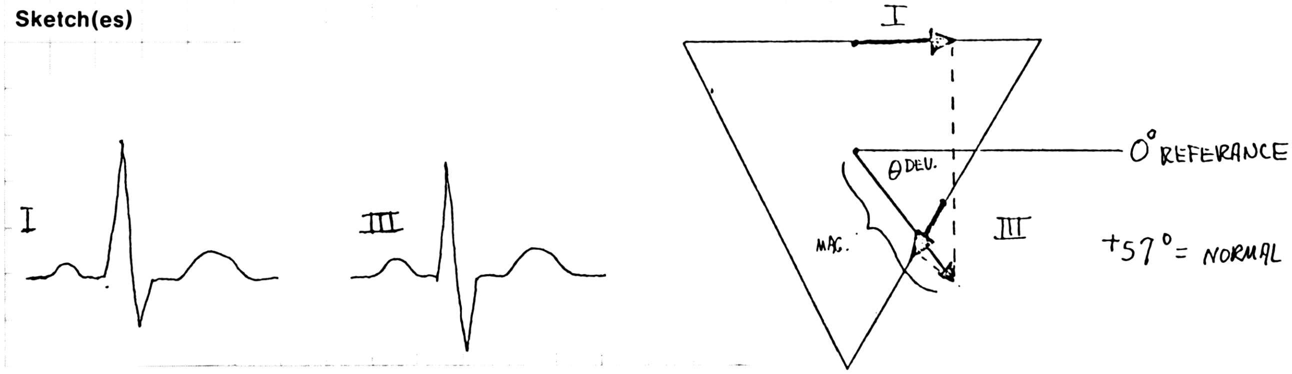
$$\text{Q-T} = 0.39 \quad \text{R-R} \pm .04$$

Operating Limits and Warnings

Both positive and negative deflections must be entered for each lead

Program Description II

Sketch(es)



Sample Problem(s)

Given the data as represented above in the graph:

I^+ = 3.0 mm (mv * .1) III^+ = 2.5 mm

I^- = 1.0 mm III^- = 1.5 mm

Heart rate = 75 bpm

Find the expected magnitude of lead II, the axis deviation in degrees (of the mean electric axis), the mean axis magnitude, the R-R interval, and the calculated Q-Tc interval.

Solution(s) 3 [ENT↑] 1 [A] 2.5 [ENT↑] 1.5 [B] → 3.0 Lead II

[C] → -8° (left axis deviation – slight)

[R/S] → 3.1 mean axis magnitude

75 [D] → 0.80 sec., R-R interval

(optional) 0.80 [D] → 75, heart rate

[E] → 0.35 sec, Q-Tc interval

Reference(s)

Schaub, Frank A., Fundamentals of Clinical Electrocardiography, pgs. 15, 23-26, Geigy Pharmaceuticals, New York, 1966.

This program is a translation of the HP-65 Users' Library Program # 00455A submitted by Steven A. Conrad.

User Instructions

BASIC EKG DETERMINATIONS

$I^{\pm}$	$III^{\pm}$	dev.	R-R	Q-Tc

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input lead I				
	positive deviation	mm	↑		
	negative deviation	mm	A		III
3	Input lead III				
	positive deviation	mm	↑		
	negative deviation	mm	B		lead II
4	Compute mean axis				
	deviation		C		degrees
	magnitude		R/S		mm
5	Input heart rate or	bpm	D		R-R,sec.
	input R-R interval	sec	D		rate,bpm
6	Compute Q-Tc		E		sec.
	(for a new case, go to step 2)				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	input lead I
002	-	-45	subt. neg. deviat.
003	STO1	35 01	store lead I in 1
004	DSP0	-63 00	prompting info for
005	1	01	lead III
006	1	01	
007	1	01	
008	RTN	24	
009	*LBLB	21 12	input lead III
010	-	-45	subt. neg. deviat.
011	STO3	35 03	store lead III in 3
012	RCL1	36 01	compute lead II
013	+	-55	
014	STO2	35 02	store lead II in 2
015	DSP1	-63 01	compute the Y point
016	PRTX	-14	of rectangular
017	RTN	24	coordinates where
018	*LBLC	21 13	X point is lead I
019	RCL1	36 01	
020	ENT↑	-21	
021	.	-62	
022	5	05	
023	7	07	
024	7	07	
025	4	04	
026	x	-35	
027	RCL3	36 03	
028	ENT↑	-21	
029	1	01	
030	.	-62	
031	1	01	
032	5	05	
033	4	04	
034	7	07	
035	x	-35	
036	+	-55	enter Y into y and
037	ENT↑	-21	X into x registers
038	RCL1	36 01	convert to polar
039	→P	34	
040	X⇄Y	-41	move angle to x reg
041	5	05	find deviation from
042	7	07	normal (57°)
043	-	-45	
044	DSP0	-63 00	recall axis mag. to
045	PRTX	-14	to X
046	R/S	51	
047	X⇄Y	-41	
048	ABS	16 31	abs. val. of ax.mag
049	DSP1	-63 01	compute rate R-R
050	PRTX	-14	
051	RTN	24	
052	*LBLD	21 14	
053	ENT↑	-21	determine if rate
054	ENT↑	-21	or R-R was compute
055	6	06	& set proper
056	0	00	display

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	X⇄Y	-41	
058	÷	-24	
059	X≤Y?	16-35	
060	GTO5	22 05	place R-R value in
061	DSP0	-63 00	the X register
062	PRTX	-14	
063	RTN	24	
064	*LBL5	21 05	
065	DSP2	-63 02	
066	PRTX	-14	
067	RTN	24	
068	*LBLE	21 15	
069	X>Y?	16-34	
070	X⇄Y	-41	compute Q-T from
071	√X	54	R-R
072	.	-62	
073	3	03	
074	9	09	
075	x	-35	
076	DSP2	-63 02	
077	PRTX	-14	
078	RTN	24	
079	R/S	51	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	lead I	lead II	lead III						

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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