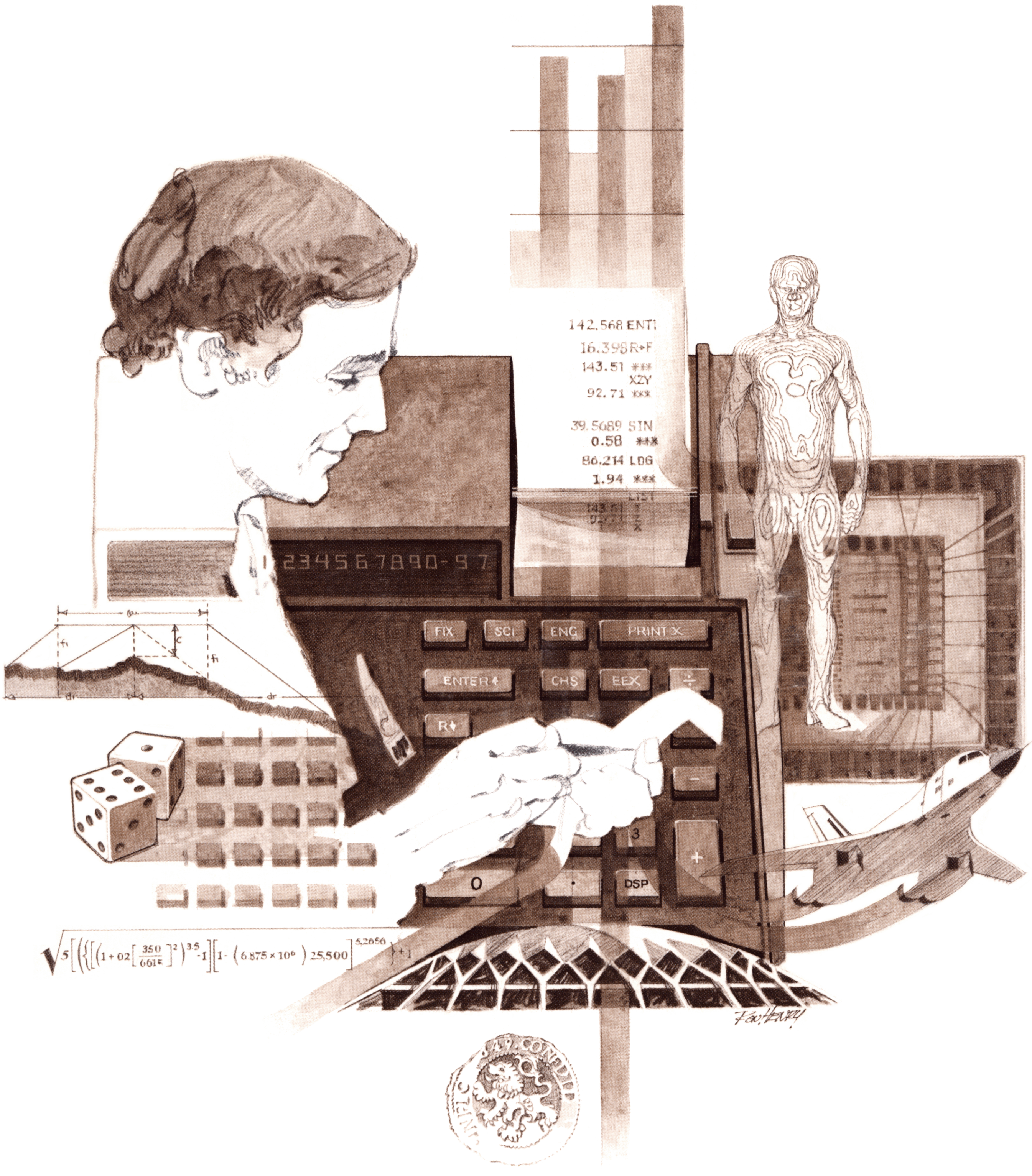
HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Pulmonary



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.

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This program calculates body surface area by either the Dubois or Boyd methods. In addition it calculates cardiac index if cardiac output is known.

Program Description I

Program Title 67 - Pulmonary Medicine/Male Spirometry Standards

Contributor's Name Richard C. Rodgers M.D.

Address 2045 Oak Street Apt 3

City San Francisco **State** CA **Zip Code** 94117

Program Description, Equations, Variables Provides calculation of predicted & percent predicted values of the following for male subjects:

Predicted values of: (Ht in cm, age in yrs.)

VC = (0.58•Ht)-(.025•Age)-4.24(liters)	Vital Capacity
FEV = (.036•Ht)-(.032•Age)-1.26(liters)	Forced Expiratory Volume*
MEFR = (.043•Ht)-(.047•Age)+2.07(liters/sec)	Max. Expiratory Flow Rate
MVV = (.9•Ht)-(1.51•Age)+27(liters)	Max. Ventilatory Volume **
RV = (.03•Ht)+(.015•Age)-3.75 (liters)	Residual Volume
TLC = (.094•Ht)-(.015•Age)-9.17 (liters)	Total Lung Capacity
FRC = (.051•Ht)-5.05 (liters)	Funct. Residual Capacity
FEF = (.02•Ht)-(.04•Age)+2 (liters/sec)	Forced Expiratory Flow
Actual FEF is = (.5•VC)/Δt(liters/sec)	(from 25% to 75%)
25% VC = .25•VC	
75% VC = .75•VC	

* After one second

** After twelve seconds

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s) Given Ht. = 72 in, Age = 28, measured VC = 5.2, calculate all predicted levels, % predicted for VC & FEF. ($t_{25\%}$ = .4, $t_{75\%}$ = 1.0).

Solution(s) 72[CHS][A] 28[f][A] 5.2[B] ----> 5.67 ℓ, VC_{pred}; 91.76% predicted

[f] [B] --------> 4.43 ℓ, FEV,

[C] --------> 8.62 ℓ/s, MEFR

[f] [C] --------> 149.31 ℓ.MVV

[D] --------> 2.16 ℓ, RV

[f] [D] --------> 7.60 ℓ, TLC

[E] -------- 4.28 ℓ, FRC

[f][E] ---->4.54ℓ/sFEF_{PRED};1.30(display only)

.40[R/S] -->3.90(display only)

1.0[R/S] -->4.33ℓ/s,FEF_{AC}.

95.50% PRED.

Reference(s)

1) Morris, J.F., Koski, A., & L.C. Johnson, AM. REV. RESP. DIS., 57: 103 (1971)
2) Bates et. al., RESP. FTN, IN DISEASE, Saunders (1971)
3) HP 65 program #00189A.

User Instructions

PULMONARY/MALE STANDARDS

1					2
Age(yrs)	FEV_1	MVV	TLC	FEF → %	
Ht(cm,-in)	VC	MEFR	RV	FRC	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Enter sides 1 and 2 of card			
2.	Input height	cm or -in	A	cm
3.	Input age	yrs	f A	yrs.
4.	Input measured value (optional) and calculate:			
	a) Predicted VC*		B	VC(ℓ)*
	b) Predicted FEV_1*		f b	FEV_1(ℓ)*
	c) Predicted MEFR*		C	MEFR(ℓ/S)*
	d) Predicted MVV*		f c	MVV(ℓ)*
	e) Predicted RV*		D	RV(ℓ)*
	f) Predicted TLC*		f d	TLC(ℓ)*
	g) Predicted FRC*		E	FRC(ℓ)*
	* Followed by % of predicted if measured value was input initially.			
5.	Input measured VC (not necessary if entered above), calculate predicted FEF and display 25% VC	VC(ℓ)	f e	FEF_{pr}(ℓ/S) 25% VC
6.	Input time associated with this value from spirogram and display 75% VC	$t_{25\%}$	R/S	75% VC
7.	Input time associatedwith this value	$t_{75\%}$	R/S	
8.	Actual FEF is now displayed, followed by % Predicted			FEF_{ac}(ℓ/S) % Pred.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Convert & store HT
002	X>0?	16-44	
003	GTO0	22 00	
004	CHS	-22	
005	2	02	
006	.	-62	
007	5	05	
008	4	04	
009	x	-35	
010	*LBL0	21 00	
011	STO0	35 00	HT→(o)
012	RTN	24	
013	*LBLa	21 16 11	Store age
014	STO1	35 01	Age →(1)
015	RTN	24	
016	*LBLB	21 12	VC routine
017	STO2	35 02	VC →(2)
018	RCL0	36 00	
019	.	-62	
020	0	00	
021	5	05	
022	8	08	
023	x	-35	
024	RCL1	36 01	
025	.	-62	
026	0	00	
027	2	02	
028	5	05	
029	x	-35	
030	-	-45	
031	4	04	
032	.	-62	
033	2	02	
034	4	04	
035	-	-45	
036	GTO2	22 02	
037	*LBLb	21 16 12	FEV, routine
038	RCL0	36 00	
039	.	-62	
040	0	00	
041	3	03	
042	6	06	
043	x	-35	
044	RCL1	36 01	
045	.	-62	
046	0	00	
047	3	03	
048	2	02	
049	x	-35	
050	-	-45	
051	1	01	
052	.	-62	
053	2	02	
054	6	06	
055	-	-45	
056	GTO2	22 02	
057	*LBLC	21 13	MEFR routine
058	RCL0	36 00	
059	.	-62	
060	0	00	
061	4	04	
062	3	03	
063	x	-35	
064	RCL1	36 01	
065	.	-62	
066	0	00	
067	4	04	
068	7	07	
069	x	-35	
070	-	-45	
071	2	02	
072	.	-62	
073	0	00	
074	7	07	
075	+	-55	
076	GTO2	22 02	
077	*LBLc	21 16 13	MVV routine
078	RCL0	36 00	
079	.	-62	
080	9	09	
081	x	-35	
082	RCL1	36 01	
083	1	01	
084	.	-62	
085	5	05	
086	1	01	
087	x	-35	
088	-	-45	
089	2	02	
090	7	07	
091	+	-55	
092	GTO2	22 02	
093	*LBLD	21 14	RV routine
094	RCL0	36 00	
095	.	-62	
096	0	00	
097	3	03	
098	x	-35	
099	RCL1	36 01	
100	.	-62	
101	0	00	
102	1	01	
103	5	05	
104	x	-35	
105	+	-55	
106	3	03	
107	.	-62	
108	7	07	
109	5	05	
110	-	-45	
111	GTO2	22 02	

REGISTERS

0	1	2	3	4	5	6	7	8	9
HT(CM)	Age(yrs)	VC actual	$t_{25\%}$	FEF pred					
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
112	*LBLd	21 16 14	TLC routine
113	RCL0	36 00	
114	.	-62	
115	0	00	
116	9	09	
117	4	04	
118	x	-35	
119	RCL1	36 01	
120	.	-62	
121	0	00	
122	1	01	
123	5	05	
124	x	-35	
125	-	-45	
126	9	09	
127	.	-62	
128	1	01	
129	7	07	
130	-	-45	
131	GTO2	22 02	
132	*LBLE	21 15	FRC routine
133	RCL0	36 00	
134	.	-62	
135	0	00	
136	5	05	
137	1	01	
138	x	-35	
139	5	05	
140	.	-62	
141	0	00	
142	5	05	
143	-	-45	
144	GTO2	22 02	
145	*LBLe	21 16 15	FEF routine
146	RCL0	36 00	
147	.	-62	
148	0	00	
149	2	02	
150	x	-35	
151	RCL1	36 01	
152	.	-62	
153	0	00	
154	4	04	
155	x	-35	
156	-	-45	
157	2	02	
158	+	-55	
159	STO4	35 04	FEF pred
160	PRTX	-14	
161	F3?	16 23 03	
162	GTO1	22 01	
163	RCL2	36 02	
164	*LBL1	21 01	
165	STO2	35 02	
166	.	-62	
167	2	02	

STEP	KEY ENTRY	KEY CODE	COMMENTS
168	5	05	
169	x	-35	
170	R/S	51	
171	STO3	35 03	$t_{25\%} \rightarrow (3)$
172	RCL2	36 02	
173	.	-62	
174	7	07	
175	5	05	
176	x	-35	
177	R/S	51	
178	RCL3	36 03	
179	-	-45	
180	RCL2	36 02	
181	.	-62	
182	5	05	
183	x	-35	
184	X⇄Y	-41	
185	÷	-24	
186	PRTX	-14	
187	RCL4	36 04	
188	SF3	16 21 03	
189	GTO3	22 03	
190	*LBL2	21 02	
191	PRTX	-14	
192	*LBL3	21 03	
193	F3?	16 23 03	
194	GTO4	22 04	
195	RTN	24	
196	*LBL4	21 04	
197	÷	-24	
198	EEX	-23	
199	2	02	
200	x	-35	
201	PRTX	-14	
202	RTN	24	
203	R/S	51	
210			
220			

LABELS

A HT	B VC	C MEFR	D RV	E FRC
a AGE	b FEV_1	c MVV	d TLC	e FEF
0	1	2	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 67 - PULMONARY MEDICINE/ FEMALE SPIROMETRY STANDARDS

Contributor's Name Richard C. Rodgers, M.D.

Address 2045 Oak Street Apt 3

City San Francisco **State** Calif. **Zip Code** 94117

Program Description, Equations, Variables

Predicted values of: (Ht in cm, age in yrs.)

$VC = (.045 \cdot Ht) - (.024 \cdot age) - 2.852$	(liters)	Vital Capacity
$FEV_1 = (.035 \cdot Ht) - (.025 \cdot age) - 1.932$	(liters)	Forced Expiratory Volume*
$MEFR = (.057 \cdot Ht) - (.036 \cdot age) - 2.532$	(liters/sec.)	Max.Expiratory Flow Rate
$MVV = (.762 \cdot Ht) - (.81 \cdot age) - 6.29$	(liters)	Max.Ventilatory Volume**
$RV = (.024 \cdot Ht) + (.012 \cdot age) - 2.63$	(liters)	Residual Volume
$TLC = (.078 \cdot Ht) - (.01 \cdot age) - 7.36$	(liters)	Total Lung Capacity
$FRC = (.047 \cdot Ht) - 4.86$	(liters)	Funct.Residual Capacity
$FEF = (.02 \cdot Ht) - (.03 \cdot age) - (.00006 \cdot age^2) + 1.3$	(liters/sec.)	Forced Expiratory Flow (from 25% to 75%)

Actual $FEF = (.5\ VC)/\Delta t$, where $\Delta t = [t_{75\%} - t_{25\%}]$

$25\%VC = .25VC$

$75\%VC = .75VC$

*After one second

**After twelve seconds

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s) Given Ht. = 60 in., age = 28 yrs., measured VC = 3.0 liters, $t_{25\%}$ = .4, $t_{75\%}$ = 1.0, calculate all predicted levels and % predicted values for VC & FEF.

Solution(s) Load male spirometry card sides 1 & 2: 60 [CHS] [A] 28[f] [A]
load female spirometry card sides 1 & 2: 3[B] → 3.33ℓ, VC_{pred}; 89.98% predicted

[f] [B]→ 2.70ℓ, FEV_1
[C]→ 5.15ℓ/s, MEFR
[f] [C]→87.16ℓ, MVV
[D]→ 1.36ℓ, RV
[f] [D]→ 4.25ℓ, TLC
[E]→ 2.30ℓ, FRC

[f] [E]→3.46ℓ/s, FEF_{pred}; 0.75 (display only)
.40 [R/S]→ 2.25 (display only)
1.0 [R/S]→ 2.50 ℓ/s, FEF_{ac}
72.23 % predicted

Reference(s) 1) Morris et al., AM. REV. RESP. DIS., 57: 103 (1971).
2) Bates et al., RESP FTN. IN DISEASE, Saunders (1971).
3) HP-65 program #00190A

User Instructions

PULMONARY/FEMALE STANDARDS

	FEV. / VC	MVV / MEFR	TLC / RV	FEF→% / FRC
1	FEV.	MVV	TLC	FEF→%
2	VC	MEFR	RV	FRC

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter sides 1 & 2 of "Male Spirometry				
	Standards" program				
2	Input height	cm or -in	A		cm
3	Input age	yrs	f	A	yrs.
4	Enter sides 1 & 2 of "Female Standards" program				
5	Input measured value (optional) and calculate:				
	a) predicted VC*		B		VC(ℓ)*
	b) predicted FEV_1*		f	B	FEV_1(ℓ)*
	c) predicted MEFR*		C		MEFR(ℓ/s)*
	d) predicted MVV*		f	C	MVV(ℓ)*
	e) predicted RV*		D		RV(ℓ)*
	f) predicted TLC*		f	D	TLC(ℓ)*
	g) predicted FRC*		E		FRC(ℓ)*
	*followed by % of predicted <u>if</u> measured value				
	was input initially.				%pred.
6	Input measured VC (not necessary if input above				
	under 5a), calculate predicted FEF and	VC(ℓ)	f	E	FEF_{rr}(ℓ/S)
	Display 25% VC				25%VC
7	Input time associated with this value (from				
	spirogram) and display 75% VC	$t_{25\%}$	R/S		75% VC
8	Input time associated with this value	$t_{75\%}$	R/S		
9	Actual FEF is now displayed, followed by				FEF_{ac}(ℓ/S)
	% predicted				%pred.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLB	21 12	VC routine
002	STO2	35 02	VC→(2)
003	RCL0	36 00	
004	.	-62	
005	0	00	
006	4	04	
007	5	05	
008	x	-35	
009	RCL1	36 01	
010	.	-62	
011	0	00	
012	2	02	
013	4	04	
014	x	-35	
015	-	-45	
016	2	02	
017	.	-62	
018	8	08	
019	5	05	
020	2	02	
021	-	-45	
022	GTO2	22 02	
023	*LBLb	21 16 12	FEV, routine
024	RCL0	36 00	
025	.	-62	
026	0	00	
027	3	03	
028	5	05	
029	x	-35	
030	RCL1	36 01	
031	.	-62	
032	0	00	
033	2	02	
034	5	05	
035	x	-35	
036	-	-45	
037	1	01	
038	.	-62	
039	9	09	
040	3	03	
041	2	02	
042	-	-45	
043	GTO2	22 02	
044	*LBLC	21 13	MEFR routine
045	RCL0	36 00	
046	.	-62	
047	0	00	
048	5	05	
049	7	07	
050	x	-35	
051	RCL1	36 01	
052	.	-62	
053	0	00	
054	3	03	
055	6	06	
056	x	-35	
057	-	-45	
058	2	02	
059	.	-62	
060	5	05	
061	3	03	
062	2	02	
063	-	-45	
064	GTO2	22 02	
065	*LBLc	21 16 13	MVV routine
066	RCL0	36 00	
067	.	-62	
068	7	07	
069	6	06	
070	2	02	
071	x	-35	
072	RCL1	36 01	
073	.	-62	
074	8	08	
075	1	01	
076	x	-35	
077	-	-45	
078	6	06	
079	.	-62	
080	2	02	
081	9	09	
082	-	-45	
083	GTO2	22 02	RV routine
084	*LBLD	21 14	
085	RCL0	36 00	
086	.	-62	
087	0	00	
088	2	02	
089	4	04	
090	x	-35	
091	RCL1	36 01	
092	.	-62	
093	0	00	
094	1	01	
095	2	02	
096	x	-35	
097	+	-55	
098	2	02	
099	.	-62	
100	6	06	
101	3	03	
102	-	-45	
103	GTO2	22 02	
104	*LBLd	21 16 14	TLC routine
105	RCL0	36 00	
106	1	01	
107	7	07	
108	4	04	
109	X⇄Y	-41	
110	X>Y?	16-34	
111	GTO5	22 05	

REGISTERS

0	1	2	3	4	5	6	7	8	9
HT (Cm)	AGE (yrs)	VC actual	$t_{25\%}$	FEF pred					
S0 A	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
112	X⇄Y	-41	
113	CLX	-51	
114	*LBL6	21 06	
115	+	-55	
116	.	-62	
117	0	00	
118	7	07	
119	8	08	
120	x	-35	
121	RCL1	36 01	
122	.	-62	
123	0	00	
124	1	01	
125	x	-35	
126	-	-45	
127	7	07	
128	.	-62	
129	3	03	
130	6	06	
131	-	-45	
132	GTO2	22 02	
133	*LBL5	21 05	
134	X⇄Y	-41	
135	CLX	-51	
136	1	01	
137	GTO6	22 06	
138	*LBLE	21 15	FRC routine
139	RCL0	36 00	
140	.	-62	
141	0	00	
142	4	04	
143	7	07	
144	x	-35	
145	4	04	
146	.	-62	
147	8	08	
148	6	06	
149	-	-45	
150	GTO2	22 02	
151	*LBLe	21 16 15	FEF routine
152	RCL0	36 00	
153	.	-62	
154	0	00	
155	2	02	
156	x	-35	
157	RCL1	36 01	
158	.	-62	
159	0	00	
160	3	03	
161	x	-35	
162	-	-45	
163	RCL1	36 01	
164	X²	53	
165	6	06	
166	EEX	-23	
167	5	05	
168	CHS	-22	
169	x	-35	
170	-	-45	
171	1	01	
172	.	-62	
173	3	03	
174	+	-55	
175	STO4	35 04	FEF pred
176	PRTX	-14	
177	F3?	16 23 03	
178	GTO1	22 01	
179	RCL2	36 02	
180	*LBL1	21 01	
181	STO2	35 02	
182	.	-62	
183	2	02	
184	5	05	
185	x	-35	
186	R/S	51	
187	STO3	35 03	$t_{25\%} \to (3)$
188	RCL2	36 02	
189	.	-62	
190	7	07	
191	5	05	
192	x	-35	
193	R/S	51	
194	RCL3	36 03	
195	-	-45	
196	RCL2	36 02	
197	.	-62	
198	5	05	
199	x	-35	
200	X⇄Y	-41	
201	÷	-24	
202	PRTX	-14	
203	RCL4	36 04	
204	SF3	16 21 03	
205	GTO3	22 03	
206	*LBL2	21 02	
207	PRTX	-14	
208	*LBL3	21 03	
209	F3?	16 23 03	
210	GTO4	22 04	
211	RTN	24	
212	*LBL4	21 04	
213	÷	-24	
214	EEX	-23	
215	2	02	
216	x	-35	
217	PRTX	-14	
218	RTN	24	
219	R/S	51	

LABELS

A	B VC	C MEFR	D RV	E FRC
a	b FEV1	c MVV	d TLC	e FEF
0	1	2	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

PULMONARY PROGRAM SERIES

The following programs may be used in a series to carry out the many calculations in a particular medical procedure. The following is an example from a respiratory intensive care unit. This example is fairly complicated. Before attempting it, 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.

Respiratory Intensive Care Example:

This is an example of the types of complicated calculations that might be done in a respiratory intensive care situation with integral blood gas lab. Many entered and calculated parameters are used by later programs. Calculations start from uncorrected blood parameters and it is assumed that O_2 saturations are not measured. Venous blood parameters are computed first, so that arterial values will be left in memory for later use in the ventilation/perfusion calculations. O_2 saturation and content is calculated before temperature correction.

PROGRAM	INPUTS	OUTPUTS
VENOUS BLOOD:		
BLOOD ACID - BASE STATUS	PCO_2=44 mmHg; pH=7.375; Hgb=15 gm/100 ml	TCO_2=26.22 mmol/ℓ BE=0.01 mEq/ℓ
VIRTUAL PO_2 & O_2 SATURATION & CONTENT	PO_2=40 mmHg; (PCO_2); (pH): BT =39°C (VPO_2); (Hgb)	VPO_2=34.64 mmHg (in display, reg.) Est. Sat. =66.54%; C_vO_2 = 13.48 Vol.%
ANAEROBIC PCO_2 & pH CHANGE	(PCO_2); (pH); (BT)	PCO_2 =48.02 mmHg; pH = 7.35
ANAEROBIC PO_2 CHANGE	(SAT); (PO_2); (BT)	PO_2 =46.15 mmHg
ARTERIAL BLOOD:		
BLOOD ACID-BASE STATUS	PCO_2 = 40mmHg; pH=7.4; (Hgb)	TCO_2 =25.18 mmol/ ℓ BE = -0.04mEq/ ℓ
VIRTUAL PO_2 & O_2 SATURATION & CONTENT	PO_2 = 90mmHg; (PCO_2); (pH); (BT) (VPO_2); (Hgb)	VPO_2 = 80.59 mmHg (in display reg.) Est. Sat. = 95.91% C_aO_2 =19.53 Vol. %
ANAEROBIC PCO_2 & pH CHANGE	(PCO_2); (pH); (BT)	PCO_2 =43.65 mmHg; pH=7.37
ANAEROBIC PO_2 CHANGE	(SAT); (PO_2); (BT)	PO_2 =102.19 mmHg

VENTILATION/PERFUSION:

DEAD SPACE FRACTION	$\dot{V}CO_2$ =240 ml/min; $\dot{V}O_2$ = 300 ml/min; (P_aCO_2); $\dot{V}_E$ = 7.4 ℓ/min	R_Q = 0.80; $\dot{V}_A$ = 4.74 ℓ/min; V_D/V_T = 0.36
ALVEOLAR-ARTERIAL OXYGEN TENSION DIFFERENCE	P_IO_2 =200 mmHg; (P_aO_2); (P_aCO_2); (R_Q)	A-a Diff =46.12mmHg; P_AO_2 = 148.31 mmHg (in display reg.)
VIRTUAL PO_2 & O_2 SATURATION	(P_AO_2); (Hgb)	Sat. = 98.91% C_AO_2 =20.34 Vol. % (in display reg.)
PHYSIOLOGIC SHUNT & FICK	(C_AO_2); (C_aO_2); (C_vO_2); ($\dot{V}O_2$)	CO = 4.96 ℓ/min; SHUNT = 11.85%
BODY SURFACE AREA (Dubois)	Ht = -69 in.; Wt =52kg (CO)	Ht =175.26 cm; BSA = 1.63 m^2; CI = 3.04 ℓ/min/m^2.

For repetitive series of calculations we recommend that you make up a work sheet for recording the entries and results, and make copies of it. This will not only serve as a guide to insure that programs are run in the correct sequence, but it will also serve as a record of calculations completed. It should be in a format which will permit direct inclusion in the patient's record.

Program Description I

Program Title LUNG DIFFUSION

Contributor's Name Hewlett Packard

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables This program evaluates the equation to calculate the lung diffusion capacity (DLCO) using the single breath method.

Equation Used:

$$DLCO = \frac{V_A(0.084)}{t_{BH}} \ln \frac{F_A CAR}{F_I CAR} \quad \frac{0.3}{F_A CO}$$

Note:

The initial concentration of carbon monoxide ($F_I CO$) is assumed to be 0.3%. If a different standard value for $F_I CO$ is desired, it may be entered for use as desired by pressing [f] [A].

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

1) In this example, the carrier gas is helium. Calculate the lung diffusing capacity using an initial helium concentration of 10%, an alveolar helium concentration of 8%, an alveolar carbon monoxide concentration of 0.159%, an initial carbon monoxide concentration of 0.3%, a breath holding time of 10 seconds, and an alveolar volume of 4930 milliliters.

2) For same data; calculate lung diffusing capacity assuming an initial carbon monoxide concentration of 0.45%.

Solution(s)

1) 10 [A] 8[B] .159 [C] 10 [D] 4930 [E] → 17.05 ml CO/min./mmHg

2) If problem 1) has already been run:

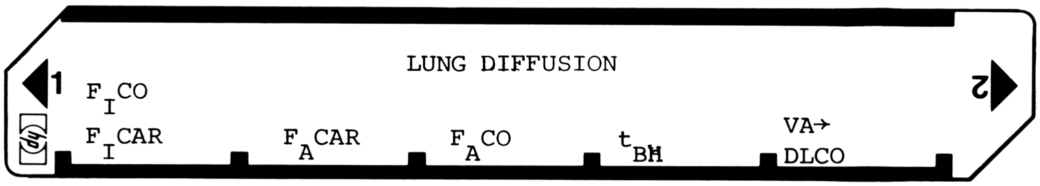
.45 [f] [A] 4930 [E] →33.84 ml/CO/min/mmHg.

If problem 1) has not been run then do: .45 [f] [A] and return to 1).

Reference(s) This program is a modification of the Users' Library program #00191A submitted by Hewlett Packard.

Comroe, et.al., The Lung, Year Book Medical Publishers Inc., 1962.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
1'	Optional: if F_ICO other than 0.3% is to be used enter it	F_ICO,%	f	A	F_ICO%
2	Input in any order				
	F_ICAR	%	A		F_ICAR
	and F_ACAR	%	B		F_ACAR
	and F_ACO	%	C		F_ACO
	and t_{BH}	seconds	D		t_{BH}
3	Input V_A and calculate DLCO	V_A(ml)	E		DLCO

<u>Detailed User Instructions:</u>

The program requires five items of input information. They may be input in any order with the exception of the alveolar volume which must be input last. The program is operated as follows: Input initial concentration of carrier in percent (F_ICAR) press [A]. Input alveolar carrier concentration in percent (F_ACAR), press [B]. Input alveolar carbon monoxide concentration in percent (F_ACO), press [C]. Input breath hold time in seconds (t_{BH}), press [D]. Input alveolar volume in milliliters (V_A), press [E], and the display shows the lung diffusing capacity (DLCO).

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Store $F_I CO$ (%)
002	ENT↑	-21	
003	ENT↑	-21	
004	.	-62	
005	3	03	
006	÷	-24	
007	STO4	35 04	Sto modified $F_I CO$
008	SF0	16 21 00	
009	R↓	-31	Display $F_I CO$
010	RTN	24	
011	*LBLA	21 11	Input $F_I CAR$
012	STO1	35 01	
013	RTN	24	
014	*LBLB	21 12	Input $F_A CAR$
015	STO2	35 02	
016	RTN	24	
017	*LBLC	21 13	Input $F_A CO$
018	STO3	35 03	
019	RTN	24	
020	*LBLD	21 14	Input t_{BH}
021	STO8	35 08	
022	RTN	24	
023	*LBLE	21 15	Input VA & calculate DLCO
024	ENT↑	-21	
025	.	-62	
026	0	00	
027	8	08	
028	4	04	
029	x	-35	
030	RCL8	36 08	
031	÷	-24	
032	RCL2	36 02	
033	ENT↑	-21	
034	RCL1	36 01	
035	÷	-24	
036	.	-62	
037	3	03	
038	F0?	16 23 00	Was $F_I CO$ stored?
039	GSB1	23 01	Yes
040	RCL3	36 03	
041	÷	-24	
042	x	-35	
043	LN	32	
044	x	-35	
045	PRTX	-14	DLCO
046	RTN	24	
047	*LBL1	21 01	Recall reg 4 & calc. $F_I CO$
048	RCL4	36 04	
049	x	-35	
050	RTN	24	
051	R/S	51	

FLAGS	
0	$F_I CO$
1	
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
	$F_I CAR$	$F_A CAR$	$F_A CO$	$F_I CO/.3$				t_{BH}	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title WATER VAPOR PRESSURE AND RESPIRATORY GAS CONVERSIONS

Contributor's Name Users' Library, Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables This program allows the user to convert among three commonly used systems of respiratory gas volume measurement. The first part calculates water vapor pressure at a given ambient temperature; the result is used in converting to or from ambient conditions. It may be used alone if only the partial pressure of water vapor is desired. The balance of the program is used for the actual conversion of the gas volumes.

Equations Used:

$$P_{H_2O} = 10^{a+bT_A^{-1} + cT_A^{-2} + d\,T_A^{-3}}$$

where

T_A = ambient temperature, K

a = 7.522467

b = -1223.31

c = -222 613.7

d = 12 323 432

P_{H_2O} = water vapor pressure, torr

Operating Limits and Warnings

Program Description I

Program Title WATER VAPOR PRESSURE AND RESPIRATORY GAS CONVERSIONS

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

$$V_{STPD} = \frac{P_{BAR} - P_{H_2O}}{T_A} V_{ATPS} \frac{273}{760}$$

$$V_{STD} = \frac{(P_{BAR} - 47)}{310} V_{BTPS} \frac{273}{760}$$

$$V_{ATPS} = \frac{T_A}{(P_{BAR} - P_{H_2O})} V_{STPD} \frac{760}{273}$$

$$B_{BTPS} = \frac{310}{(P_{BAR} - 47)} V_{STPD} \frac{760}{273}$$

ATPS = Ambient temperature and pressure saturated with water vapor:

$$P = P_{BAR} - P_{H_2O},\ T = T_A$$

BTPS = Body temperature and pressure saturated with water vapor:

$$P_{H_2O} = 47\text{mmHg},\ T = 310K$$

STPD = Standard temperature and pressure dry: P=760 mmHg, T=273K

P_{BAR} = Barometric pressure, mmHg or torr

V = Volume at condition indicated by subscript

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

1. Convert 4.3 liters BTPS at a barometric pressure of 743 mmHg to the equivalent volume at STPD.
2. Convert a volume of 4.81 liters ATPS at 83° Fahrenheit and a pressure of 765 mmHg to BTPS.

Solution(s)

1. 743 [A] 4.3 [C] [E] [D] → 3.47 liters, STPD
2. 83 [CHS] [f] [A] → 28.94 mmHg, P_{H_2O}

   765 [A] 4.81 [B] [E] [C] → 5.07 liters, BTPS

Reference(s) This program is a modification of the Users' Library program # 00192A submitted by Hewlett-Packard.

The water vapor pressure program is an approximation to the water vapor pressure table in Scientific Tables published by Ciba-Giegy Limited, 7th Edition, 1970, and is valid for temperatures T, such that $0<T \leqslant 100°C$.

The gas conversions are based on the ideal gas laws and closely approximate the tables in Scientific Tables.

User Instructions

WATER VAPOR PRESSURE AND RESPIRATORY GAS CONVERSIONS

1 TEMP→ P_{H_2O} 2

PBAR | ATPS | BTPS | STPD | →

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load side 1 and side 2				
	If conversion between BTPS and STPD only is				
	needed go to 3; otherwise go to 2.				
2	Input ambient temp and calculate water				
	vapor pressure	°C or −°F	f	A	P_{H_2O} (mmHg)
3	Input P_{BAR}	P_{BAR} (mmHg)	A		P_{BAR} (mmHg)
	and volume at ATPS	volume	B		volume
	or volume at BTPS	volume	C		volume
	or volume at STPD	volume	D		volume
4	Calculate desired volume at				
	ATPS		E	B	volume
	BTPS		E	C	volume
	STPD		E	D	volume
5	For a new case with same water vapor conditions				
	go to step 3 otherwise go to step 2				
	Detailed User Instructions:				
	In order to convert between BTPS volumes and				
	STPD volumes, only steps 3 & 4 need be used.				
	In such a case input the barometric pressure				
	in millimeters of mercury and press [A].				
	Next, input the volume of the gas in either				
	BTPS units or STPD units, and press either				
	[C] or [D] to define the volume system.				
	Next, press [E] and then either [D] or [C]				
	depending on the conversion desired.				
	If conversion is desired to or from ATPS				
	conditions the entire program must be used. To				
	do this, input the ambient temperature				
	(positive for °C, negative for °F), and press				
	[f] [A]. Next, input the barometric pressure in				
	millimeters of mercury and press [A]. Then,				
	input the volume to be converted, followed				
	by the units of volume. (For example, if 5				
	liters STPD is to be converted, press [5] then				
	press [D].) Next, press [E] then press the				
	key corresponding to the system in which the				
	volume is desired.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Input temperature &
002	X>0?	16-44	if in °F, convert to
003	GTO0	22 00	°C
004	3	03	
005	2	02	
006	+	-55	
007	1	01	
008	.	-62	
009	8	08	
010	CHS	-22	
011	÷	-24	
012	*LBL0	21 00	
013	2	02	
014	7	07	
015	3	03	
016	+	-55	°K = °C + 273
017	STO2	35 02	
018	1/X	52	
019	STO1	35 01	Calculate water
020	7	07	vapor pressure
021	.	-62	
022	5	05	
023	2	02	
024	2	02	
025	4	04	
026	6	06	
027	7	07	
028	ENT↑	-21	
029	1	01	
030	2	02	
031	2	02	
032	3	03	
033	.	-62	
034	3	03	
035	1	01	
036	RCL1	36 01	
037	x	-35	
038	-	-45	
039	2	02	
040	2	02	
041	2	02	
042	6	06	
043	1	01	
044	3	03	
045	.	-62	
046	7	07	
047	RCL1	36 01	
048	ENT↑	-21	
049	x	-35	
050	x	-35	
051	-	-45	
052	1	01	
053	2	02	
054	3	03	
055	2	02	
056	3	03	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	4	04	
058	3	03	
059	2	02	
060	RCL1	36 01	
061	x	-35	
062	RCL1	36 01	
063	ENT↑	-21	
064	x	-35	
065	x	-35	
066	+	-55	
067	10^x	16 33	
068	STO8	35 08	
069	PRTX	-14	Store & print water
070	RTN	24	vapor pressure
071	*LBLA	21 11	
072	STO1	35 01	Store P_{BAR}
073	RTN	24	
074	*LBLB	21 12	
075	F1?	16 23 01	Input or output?
076	GTO1	22 01	
077	STO4	35 04	Convert ATPS to STPD
078	RCL2	36 02	
079	RCL1	36 01	
080	RCL8	36 08	
081	*LBL4	21 04	
082	-	-45	
083	÷	-24	
084	÷	-24	Convert to STPD
085	.	-62	
086	3	03	
087	5	05	
088	9	09	
089	2	02	
090	x	-35	
091	STO3	35 03	
092	RCL4	36 04	
093	RTN	24	
094	*LBL1	21 01	
095	RCL3	36 03	Convert STPD prev-
096	RCL2	36 02	iously stored to
097	RCL1	36 01	ATPS
098	RCL8	36 08	
099	*LBL3	21 03	
100	-	-45	
101	÷	-24	
102	x	-35	
103	2	02	
104	.	-62	
105	7	07	
106	8	08	
107	4	04	
108	x	-35	
109	PRTX	-14	Print result
110	CF1	16 22 01	Clear flag
111	RTN	24	
112	*LBLC	21 13	

REGISTERS

0	1 $1/T, P_{BAR}$	2 T(K)	3	4	5	6	7	8 P_{H_2O}	9
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	F1?	16 23 01	
114	GTO2	22 02	
115	STO4	35 04	
116	3	03	
117	1	01	Set stack for
118	0	00	conversion from BTPS
119	RCL1	36 01	to STPD and go to 4
120	4	04	
121	7	07	
122	GTO4	22 04	
123	*LBL2	21 02	
124	RCL3	36 03	
125	3	03	
126	1	01	
127	0	00	Set stack for conv-
128	RCL1	36 01	ersion from STPD to
129	4	04	BTPS
130	7	07	
131	GTO3	22 03	
132	*LBLD	21 14	
133	F1?	16 23 01	
134	GTO0	22 00	Input, output?
135	STO3	35 03	
136	RTN	24	Store STPD
137	*LBL0	21 00	
138	RCL3	36 03	
139	PRTX	-14	
140	CF1	16 22 01	Recall and print STPD
141	RTN	24	Clear flag
142	*LBLE	21 15	
143	SF1	16 21 01	
144	RTN	24	Set flag for calcul-
145	R/S	51	ations

LABELS

A	B	C	D	E
P_{BAR}	ATPS	BTPS	STPD	calculate
a $T \to P_{H_2O}$	b	c	d	e
0	1 const	2 const	3 calc	4 STPD
5	6	7	8	9

FLAGS

0	
1	calculate
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 VENTILATOR SETUP AND CORRECTIONS (RADFORD)

Contributor's Name Users' Library, Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables This program calculates the initial tidal volume for a ventilator patient. The first part calculates an approximation to the Radford nomogram tidal volume with correction for ventilator dead space only. The second part corrects the tidal volume for altitude, patient's temperature, daily activity, use of a tracheotomy tube, and metabolic acidosis in anesthesia.

Equations Used:

V_A = Alveolar minute volume $=10^{(C_1 \text{LOG WT}+C_2)/100}$ ml/min.

TV_A = Alveolar tidal volume = $\dfrac{V_A}{r}$ ml

TV_{bas} = Basal tidal volume = (V_{T_A} + Wt (lbs)) ml

TV_{corr} = Basal tidal volume + ventilator dead space

where

r = Breathing rate (breaths per minute)

Operating Limits and Warnings

Warning:

This program yields an approximation to the Radford nomogram. The nomogram may not be applied with confidence to patients with muscular activity or abnormal lung function.

Apply only the corrections which pertain to the patient for whom the program is being run.

Program Description I

Program Title MEDICAL: VENTILATOR SETUP AND CORRECTIONS (RADFORD)

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

For females:

$$C_1 = \begin{cases} 124; & Wt \leqslant 8kg \\ 61; & 8kg < Wt \leqslant 23kg \\ 44.2; & Wt > 23kg \end{cases}$$

$$C_2 = \begin{cases} 193; & Wt \leqslant 8kg \\ 249; & 8kg < Wt \leqslant 23kg \\ 272; & Wt > 23kg \end{cases}$$

For males:

$$C_1 = \begin{cases} 124: & Wt \leqslant 8kg \\ 61; & Wt > 8kg \end{cases}$$

$$C_2 = \begin{cases} 193; & Wt \leqslant 8kg \\ 249; & Wt > 8kg \end{cases}$$

Corrections:

Temperature: +5% per °F above 99° (rectal)

Altitude: +5% per 2000' above sea level

Activity: +10%

Tracheotomy: $-\frac{1}{2}$ body weight in pounds

Metabolic acidosis in anesthesia: +20%

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

Example:

1) Calculate the predicted tidal volume for a 170 pound comatose male having a breath rate of 15 breaths per minute, ventilator dead space of 25 milliliters, fever of 101° Fahrenheit, who is located 500 feet above sea level.

2) What would be the corrected tidal volume if this patient were in metabolic acidosis?

Solution(s) 1) 170 [CHS] [A] 1[B] 15[C] [D] →462.15ml, Basal Tidal Volume

25 [E]→487.15ml, Tidal Volume Corrected for Deadspace

101 [CHS] [f] [A] →535.86ml, TVcorr (body temp corr.)

500 [CHS] [f] [B] →542.56ml, TVcorr (altitude corr.)

2) [f] [E] →651.07ml, TVcorr. for metabolic acidosis

Reference(s) This program is a modification of the Users' Library Program #00193A submitted by Hewlett-Packard.

Radford, Edward P., "Ventilation Standards for Use in Artificial Respiration," Journal of Applied Physiology, 7:451, 1955.

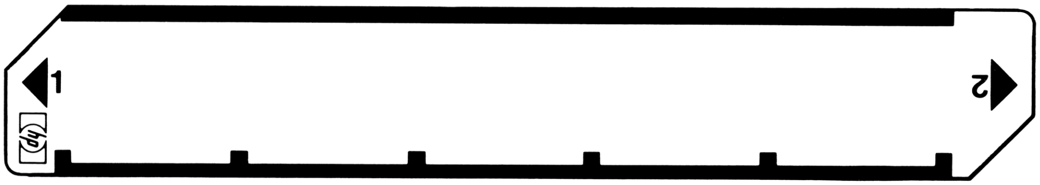
User Instructions

VENTILATOR SETUP AND CORRECTIONS (RADFORD)

TEMP	ALT	ACTIVE	TRACH	MET ACID
WT	SEX	RATE	$\rightarrow T_{VBAS}$	$DS_V \rightarrow TV_c$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load sides 1 and 2				
2	Input weight (+Kg or -lb.)	Kg or -lb	A		Wt, (Kg)
3	Input sex (0 for female, 1 for male)	0=F,1=M	B		0=F,1=M
4	Input breathing rate	BR/min	C		BR/min
5	Calculate basal tidal volume		D		TVbas, (ml)
6	Input ventilator dead space	DS_V, ml	E		TV_{corr} (ml)
7	Input patient temperature (+°C,-°F)	°C or -°F	f	A	TV_{corr} (ml)
8	Input altitude (+meters, -feet)	m or -ft	f	B	TV_{corr} (ml)
9	For minor daytime activity				
	(non comatose)		f	C	TV_{corr} (ml)
	or, for tracheotomy		f	D	TV_{corr} (ml)
	or, for metabolic acidosis during anesthesia		f	E	TV_{corr} (ml)
	Detailed User Instructions:				
	To calculate the tidal volume required by a				
	patient, load the program into the calculator.				
	Then input patient's weight in kilograms will				
	be displayed. Next, input patient's sex: [0]				
	for female, or [1] for male, and press [B].				
	Input breathing rate at which the patient will				
	be ventilated and press [C]. To calculate				
	basal tidal volume (uncorrected) press [D].				
	This value is the tidal volume approximation				
	to the Radford nomogram.				
	Next, input ventilator dead space, followed				
	by [E], giving the tidal volume corrected for				
	the ventilator dead space.				
	The remainder of the program applies the				
	corrections specified in the Radford nomogram.				
	Input patient's temperature in degrees Celsius				
	or in degrees Fahrenheit negatively and press				
	[f] [A] to obtain the tidal volume corrected				
	for patient temperature. Next input altitude				
	in meters or in feet negatively and press [f]				
	[B] to obtain tidal volume corrected for				
	altitude. To correct tidal volume for minor				
	daytime activity of a non-comatose patient,				

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Detailed User Instructions: con't			
	Press [f] [C]. If patient is fitted with a			
	tracheotomy or endotracheal tube, press [f] [D]			
	to obtain the corrected tidal volume. If the			
	ventilator is being used during the administ-			
	ration of anesthesia and the patient exhibits			
	metabolic acidosis, press [f] [E] to obtain			
	corrected tidal volume.			
	Note:			
	Apply only the corrections which pertain to			
	the patient for whom the program is being run.			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	X<0?	16-45	
003	GSB0	23 00	
004	STO6	35 06	Store wt as Kg
005	RTN	24	
006	*LBL0	21 00	Convert LB to Kg
007	2	02	
008	.	-62	
009	2	02	
010	CHS	-22	
011	÷	-24	
012	RTN	24	
013	*LBLB	21 12	
014	STO3	35 03	Store sex
015	RTN	24	
016	*LBLC	21 13	
017	STO8	35 08	Store heart rate
018	RTN	24	
019	*LBLD	21 14	
020	RCL3	36 03	
021	X=0?	16-43	Male or female?
022	GTO1	22 01	
023	*LBL2	21 02	Tidal volume for
024	8	08	male
025	RCL6	36 06	Constant inputs
026	X≤Y?	16-35	
027	GTO3	22 03	
028	2	02	
029	4	04	
030	9	09	
031	ENT↑	-21	
032	6	06	
033	1	01	
034	GTO4	22 04	
035	*LBL3	21 03	
036	1	01	
037	9	09	
038	3	03	
039	ENT↑	-21	
040	1	01	
041	2	02	
042	4	04	
043	*LBL4	21 04	Common male/female
044	RCL6	36 06	calc.
045	LOG	16 32	
046	×	-35	
047	+	-55	
048	EEX	-23	
049	2	02	
050	÷	-24	
051	10^x	16 33	
052	RCL8	36 08	
053	÷	-24	
054	RCL6	36 06	
055	2	02	
056	.	-62	
057	2	02	
058	×	-35	
059	+	-55	
060	STO1	35 01	
061	PRTX	-14	
062	RTN	24	
063	*LBL1	21 01	Tidal volume for
064	2	02	females
065	3	03	
066	RCL6	36 06	Constant inputs
067	X≤Y?	16-35	
068	GTO2	22 02	
069	2	02	
070	7	07	
071	2	02	
072	ENT↑	-21	
073	4	04	
074	4	04	
075	.	-62	
076	2	02	
077	GTO4	22 04	
078	*LBLE	21 15	Calculate DS_v
079	RCL1	36 01	
080	+	-55	
081	STO1	35 01	
082	PRTX	-14	
083	RTN	24	
084	*LBLa	21 16 11	Temperature correct-
085	X>0?	16-44	ion
086	GTO0	22 00	
087	GTO1	22 01	
088	*LBL0	21 00	Convert °C to °F
089	1	01	
090	.	-62	
091	8	08	
092	×	-35	
093	3	03	
094	2	02	
095	+	-55	
096	CHS	-22	
097	*LBL1	21 01	
098	CHS	-22	
099	9	09	
100	9	09	
101	-	-45	
102	0	00	
103	X>Y?	16-34	Is temp <99°F ?
104	GTO0	22 00	Yes, no correction
105	+	-55	
106	.	-62	Do temperature
107	0	00	correction
108	5	05	
109	×	-35	
110	RCL1	36 01	
111	×	-35	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	TV		SEX			WT. (Kg)		RATE	
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
112	RCL1	36 01	
113	+	-55	
114	STO1	35 01	
115	PRTX	-14	
116	RTN	24	
117	*LBL0	21 00	
118	RCL1	36 01	
119	RTN	24	
120	*LBLb	21 16 12	Altitude correction
121	X<0?	16-45	Meters or feet
122	GTO2	22 02	
123	3	03	Convert meters to
124	.	-62	feet if necessary
125	2	02	
126	8	08	
127	CHS	-22	
128	x	-35	
129	*LBL2	21 02	
130	CHS	-22	
131	2	02	
132	EEX	-23	Do altitude correct-
133	3	03	ion
134	÷	-24	
135	RCL1	36 01	
136	x	-35	
137	.	-62	
138	0	00	
139	5	05	
140	x	-35	
141	RCL1	36 01	
142	+	-55	
143	STO1	35 01	
144	PRTX	-14	
145	RTN	24	
146	*LBLc	21 16 13	
147	RCL1	36 01	
148	.	-62	Activity addition of
149	1	01	+10%
150	x	-35	
151	RCL1	36 01	
152	+	-55	
153	STO1	35 01	
154	PRTX	-14	
155	RTN	24	
156	*LBLd	21 16 14	
157	RCL1	36 01	Trach. correction
158	RCL6	36 06	
159	1	01	
160	.	-62	
161	1	01	
162	x	-35	
163	-	-45	
164	STO1	35 01	
165	PRTX	-14	
166	RTN	24	
167	*LBLe	21 16 15	Metabolic acid
168	RCL1	36 01	correction of +20%
169	.	-62	
170	2	02	
171	x	-35	
172	RCL1	36 01	
173	+	-55	
174	PRTX	-14	
175	RTN	24	
176	R/S	51	
180			
190			
200			
210			
220			

LABELS

A WT	B SEX	C RATE	D TV_{BAS}	E $DS_V \rightarrow TV_C$
a TEMP	b ALT	c	d ACTIVE	e MET ACID
0 USED	1 USED	2 USED	3 CONST.	4 CALC.
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 ARTERIAL CO_2 NORMALIZATION

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables The Arterial CO_2 Normalization Program calculates the additional dead space (DS_{ADD}) needed in a hypocapnic ventilator patient's breathing circuit to raise the arterial CO_2 partial pressure (P_aCO_2) to 40 millimeters of mercury (mmHg).

Equations Used:

$$DS_{ADD} = \frac{TV\text{-}DS}{40-\Delta P_{co2}}(40-P_aCO_2)$$

$$\Delta P_{co2} = P_aCO\text{-}P_ECO_2 \text{ or } P_aCO_2\text{-}5 \text{ if } P_ECO_2 \text{ is not entered}$$

$$TV\text{-}DS=TV - [1.47Wt(kg)+DS_p]$$

Operating Limits and Warnings

The additional dead space required by this program must be inserted into the patient's breathing circuit without changing the ventilator rate or tidal volume.

Measure and input the mixed expired CO_2 partial pressure if lung function is abnormal.

Program Description II

Sketch(es)

Sample Problem(s)

Calculate the additional dead space required by a 50 kilogram patient with a P_aCO_2 of 25 mmHg with normal lung status having a tidal volume of 900 ml and a present dead space of 25ml.

Solution(s)

50 [A] 25[B] 900[D] 25[E]→343.50ml, additional dead space

Reference(s) This program is a translation of the HP-65 Users' Library Program #00194A, submitted by Hewlett-Packard.

Suwa, Kunio; Geffin, Bennie; Pontoppidan, Hennigg; Bendixen, Henry; "A Nomogram for Dead Space Requirement During Prolonged Artificial Ventilation," Anesthesiology, v 29, 1968 Nov-Dec.

User Instructions

ARTERIAL CO_2 NORMALIZATION

1 | WT | P_aCO_2 | $P_{\bar{E}}CO_2$ | TV | $DS_p \rightarrow DS_{add}$ | 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input patient weight	kg or -lb	A		Wt(kg)
3	Input P_aCO_2	mmHg	B		P_aCO_2 (mmHg)
4	If patient lung status is normal go to step 5.				
	Otherwise input $P_{\bar{E}}CO_2$	mmHg	C		$P_{\bar{E}}CO_2$
5	Input present tidal volume	TV(ml)	D		TV(ml)
6	Input present dead space and calculate addit-				
	ional dead space.	DS(ml)	E		DS_{add}(ml)

Detailed User Instructions:

To calculate the additional dead space for the hypocapnic patient, first input the patient's weight in kilograms, or in pounds followed by [CHS]. Press [A] to display the patient's weight in kilograms. Next, input the patient's P_aCO_2 in mmHg and press [B]. If the patient's lung status is abnormal, the mixed expired CO_2 partial pressure ($P_{\bar{E}}CO_2$) must be measured and input followed by [C]. If the patient's lung function is normal, this step may be bypassed, and the $P_{\bar{E}}CO_2$ is assumed to be 5 millimeters of mercury less than the P_aCO_2. Next, input the patient's present tidal volume in milliliters, and press [D]. Finally, input the present ventilator dead space in milliliters and press [E]. The display now contains the additional rebreathing dead space which must be added to the patient's circuit to achieve P_aCO_2 normalization.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Input weight
002	X<0?	16-45	Lb?
003	GSB1	23 01	Yes
004	STO6	35 06	Sto wt in Kg
005	RTN	24	
006	*LBL1	21 01	Convert lb. to Kg
007	2	02	
008	.	-62	
009	2	02	
010	CHS	-22	
011	÷	-24	
012	RTN	24	
013	*LBLB	21 12	Input P_aCO_2 & calculate P_ECO_2
014	STO1	35 01	
015	5	05	
016	-	-45	
017	STO8	35 08	
018	RCL1	36 01	
019	RTN	24	
020	*LBLC	21 13	Store P_ECO_2
021	STO8	35 08	
022	RTN	24	
023	*LBLD	21 14	Store TV
024	STO7	35 07	
025	RTN	24	
026	*LBLE	21 15	Calculate additional dead space.
027	RCL6	36 06	
028	1	01	
029	.	-62	
030	4	04	
031	7	07	
032	x	-35	
033	+	-55	
034	RCL7	36 07	
035	X⇄Y	-41	
036	-	-45	
037	4	04	
038	0	00	
039	RCL1	36 01	
040	RCL8	36 08	
041	-	-45	
042	-	-45	
043	÷	-24	
044	4	04	
045	0	00	
046	RCL1	36 01	
047	-	-45	
048	x	-35	
049	PRTX	-14	
050	RTN	24	
051	R/S	51	

STEP	KEY ENTRY	KEY CODE	COMMENTS
060			
070			
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
	P_aCO_2					Wt.	TV	P_ECO_2	USED
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title BLOOD ACID-BASE STATUS

Contributor's Name Users' Library, Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables This program computes total plasma CO_2 and base excess from PCO_2, pH and hemoglobin concentration.

Equations:

Total plasma CO_2 is calculated from the Henderson-Hasselbalch equation:

$$TCO_2 = s \cdot PCO_2\ [1+10^{\,pH-pK}]$$

where

TCO_2 = total CO_2 in plasma, mmol/ℓ

s = solubility of CO_2 in plasma, mmol/ℓ (taken to be 0.0307)

PCO_2 = partial pressure of CO_2 in the blood, mmHg

pK = 6.11

This does not take into account the small temperature dependence of both s and pK, nor the pH dependence of pK. For this reason the formula for TCO_2 will be most accurate if 37° C values for PCO_2 and pH are used.

Operating Limits and Warnings

While Thomas has shown that this equation may produce large errors for very abnormal conditions, it matches the Siggaard-Andersen nomogram for $[BE]_b$, to within $\pm$ 1 mEq/ℓ in most cases.

Program Description I

Program Title BLOOD ACID - BASE STATUS

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

The base excess is calculated from an equation suggested by Siggaard-Andersen:

$$[BE]_b = (1-0.0143\ Hgb) \cdot ([HCO_3] - (9.5 + 1.63\ Hgb)\ (7.4-pH)\ -24)$$

where

$[BE]_b$ = Base Excess in m Eq/ℓ of blood

Hbg = Hemoglobin concentration in g/100 ml

and plasma $[HCO_3]$ is calculated from the Hendersen-Hasselbalch equation in the form

$$[HCO_3] = s \cdot PCO_2 \cdot 10^{pH - pK}$$

Siggaard-Andersen used 38°C values for PCO_2 and pH. Only small errors will result from using 37°C values, but body temperature corrected values should not be used if the patient has any significant hyper or hypothermia. If only body temperature values are known, the "Anaerobic PCO_2 and pH change" program may be used to correct them back to 37°C. (See special instructions for that program).

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

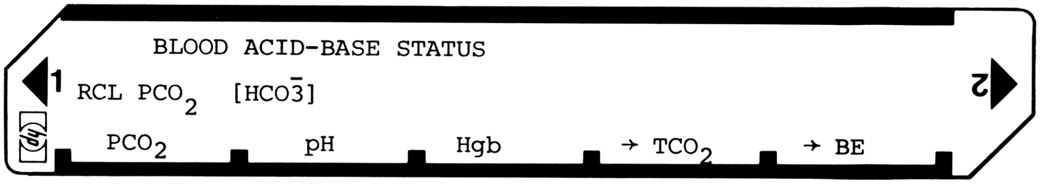
PCO_2 = 45 mmHg
pH = 7.35
Hgb = 16 g/100 ml

Solution(s) 45 [A] 7.35 [B] 16 [C] [D] → 25.39 mmol/ℓ TCO_2
[E] → -1.36 mEq/ℓ, $[BE]_b$
[f] [B]→ 24.01 mmol/ℓ, HCO_3^-]

Reference(s) This program is a translation of the HP-65 Users' Library Program # 00195A submitted by Hewlett-Packard Company.

Siggaard-Andersen, "Titratable Acid or Base of Body Fluids." Annals New York Academy of Sciences 133: 41-48, 1966. Thomas, L.J. Jr., "Algorithms for Selected Blood Acid-Base and Blood Gas Calculations," J.Appl.Physiol. 33: 154-158, 1972.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load side 1 of card				
2	Recall PCO_2 if previously stored		f	A	PCO_2, mmHg
3	Input PCO_2	PCO_2, mmHg	A		pH (if stored)
4	Input pH	pH	B		Hgb (if stored)
5	Input Hgb	Hgb (gm/100ml)	C		Hgb (gm/100ml)
6	Calculate TCO_2		D		TCO_2 (mmol/ℓ)
7	Calculate BE		E		$[BE]_b$ (mEq/ℓ)
8	Recall [HCO_3^-]		f	B	HCO_3^- (mmol/ℓ)

Detailed User Instructions

If PCO_2 has been previously stored, it may be recalled after entering the program card by pressing [f] [A]. If not, input PCO_2 and press [A]. The pH will be recalled if previously stored. If not, input pH and press [B]. The Hgb will be recalled if previously input. If not, input Hgb and press [C].

Press [D] to obtain TCO_2 in mmol/ℓ. Press [E] to obtain $[BE]_b$ in mEq/ℓ. [D] must be pressed before [E]. The plasma [HCO_3^-] may be obtained by pressing [f] [B].

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	RCL5	36 05	Recall PCO_2
003	EEX	-23	
004	2	02	
005	÷	-24	
006	RTN	24	
007	*LBLA	21 11	Input PCO_2
008	EEX	-23	
009	2	02	
010	×	-35	
011	INT	16 34	
012	RCL5	36 05	
013	FRC	16 44	
014	+	-55	
015	ST05	35 05	Store PCO_2
016	RCL6	36 06	Recall pH
017	EEX	-23	
018	3	03	
019	÷	-24	
020	RTN	24	
021	*LBLB	21 12	
022	EEX	-23	
023	3	03	
024	×	-35	
025	INT	16 34	Input pH
026	RCL6	36 06	
027	FRC	16 44	
028	+	-55	
029	ST06	35 06	
030	RCL9	36 09	Recall Hgb
031	RTN	24	
032	*LBLC	21 13	Input Hgb
033	ST09	35 09	
034	RTN	24	
035	*LBLD	21 14	Calculate TCO_2
036	RCL6	36 06	
037	EEX	-23	
038	3	03	
039	÷	-24	
040	ST01	35 01	
041	6	06	
042	.	-62	
043	1	01	
044	1	01	
045	-	-45	
046	10^x	16 33	
047	RCL5	36 05	
048	3	03	
049	2	02	
050	5	05	
051	7	07	
052	÷	-24	
053	×	-35	
054	ST08	35 08	
055	LSTX	16-63	
056	+	-55	
057	PRTX	-14	
058	RTN	24	
059	*LBLE	21 15	Calculate base excess
060	RCL9	36 09	
061	1	01	
062	.	-62	
063	6	06	
064	3	03	
065	×	-35	
066	9	09	
067	.	-62	
068	5	05	
069	+	-55	
070	RCL1	36 01	
071	7	07	
072	.	-62	
073	4	04	
074	-	-45	
075	×	-35	
076	RCL8	36 08	
077	+	-55	
078	2	02	
079	4	04	
080	-	-45	
081	1	01	
082	RCL9	36 09	
083	7	07	
084	0	00	
085	÷	-24	
086	-	-45	
087	×	-35	
088	PRTX	-14	
089	RTN	24	
090	*LBLb	21 16 12	Recall $[HCO_3^-]$
091	RCL8	36 08	
092	PRTX	-14	
093	RTN	24	
094	R/S	51	

100

110

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
	USED				$PCO_2.PO_2$	pH.BT		$H\bar{C}O_3$	Hgb

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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.

<u>Equations:</u>

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.

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

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

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

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_2orP_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	

STEP	KEY ENTRY	KEY CODE	COMMENTS
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	2	3	4	5	6	7	8	9
	Used / PO_2		CvO_2	CaO_2	Used	Used		Used / SAT	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	×	-35	
114	+	-55	
115	RCL1	36 01	
116	2	02	
117	EEX	-23	
118	3	03	
119	×	-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	×	-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	×	-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	×	-35	
153	×	-35	
154	RCL1	36 01	
155	3	03	
156	1	01	
157	×	-35	
158	+	-55	
159	EEX	-23	
160	4	04	
161	CHS	-22	
162	×	-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	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n 2	

Program Description I

Program Title ANAEROBIC PCO_2 and pH CHANGE

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables

Corrections of PCO_2 and pH for anaerobic temperature change are calculated. The equation for pH is a simplification of a formula from Severinghaus. It ignores the pH and BE dependent terms. This introduces a very small error except at extreme conditions of acid-base status and large temperature shifts. For example, at a pH of 7.2 or 7.6, the error is 0.0013 pH units per °C.

Equations Used:

$$PCO_2(BT) = PCO_2(37) \cdot 10^{0.019(T-37)}$$

$$pH(BT) = pH(37) - 0.0146\ (T-37)$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

PCO_2 = 45 mmHg

pH = 7.35

BT = 40°C

Solution(s)

45[B] 7.35 [C] 40[D] → 51.31 mmHg, PCO_2

[E] → 7.31 pH (BT)

Reference(s) This program is a translation of the HP-65 Users' Library Program #00198A submitted by Hewlett-Packard.

Severinghaus, John W., "Blood Gas Calculator," Journal of Applied Physiology, May 1966.

User Instructions

ANAEROBIC PCO_2 AND pH CHANGE

→RCL PCO_2	PCO_2 (37°)	pH (37°)	BT→PCO_2 (BT)	→pH (BT)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	If PCO_2 was previously stored recall it		A	PCO_2
3	Input PCO_2 (37°)	PCO_2 (mmHg)	B	pH(if stored)
4	Input pH (37°)	pH(37°)	C	BT(if stored)
5	Input BT and calculate PCO_2			
	(BT)	BT(°C)	D	PCO_2 (mmHg)
6	Compute pH(BT)		E	pH(BT)
	Detailed User Instructions:			
	If Sat. was previously stored in memory, it can			
	be recalled by pressing [A]. If not, skip [A]			
	and input Sat. press [B]. If PO_2(37°) was			
	previously stored, it will appear. If not,			
	input it. Press [C]. If body temperature			
	was previously stored, it will appear. If not,			
	input it in °C. Press [D]. PO_2(BT) will			
	appear and be stored in memory.			
	PO_2(BT) replaces the 37°C value in memory with			
	the body temperature value. Therefore,			
	calculation based on the 37°C values in			
	programs for virtual PO_2 and O_2 saturation &			
	content should be accomplished before this			
	program is run. If O_2 saturation has not been			
	measured, it should be estimated by using			
	program for "Virtual PO_2 and O_2 Saturation &			
	Content."			
	This program may also be used to convert PO_2			
	between any two temperatures, for example, from			
	body temperature to 37°C. To do this, first			
	determine what the desired temperature change is			
	in °C. Add this to 37°C algebraically, and			
	enter the result as BT. For example, suppose			
	values known at 41°C are to be converted to			
	37°C. The temperature change is -4°C. Add this			
	to 37°C, resulting in 33°C. Executing the			
	program with BT=33°C will then result in the			
	37°C value for PO_2.			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Recall PCO_2
002	RCL5	36 05	
003	EEX	-23	
004	2	02	
005	÷	-24	
006	RTN	24	Display PCO_2
007	*LBLB	21 12	Enter PCO_2
008	EEX	-23	
009	2	02	
010	x	-35	
011	INT	16 34	
012	RCL5	36 05	
013	FRC	16 44	
014	+	-55	
015	ST05	35 05	
016	RCL6	36 06	
017	EEX	-23	
018	3	03	
019	÷	-24	
020	RTN	24	Display pH
021	*LBLC	21 13	Enter pH
022	EEX	-23	
023	3	03	
024	x	-35	
025	INT	16 34	
026	RCL6	36 06	
027	FRC	16 44	
028	+	-55	
029	ST06	35 06	
030	LSTX	16-63	
031	EEX	-23	
032	3	03	
033	x	-35	
034	RTN	24	Display BT
035	*LBLD	21 14	Enter BT
036	3	03	
037	7	07	Calculate PCO_2
038	-	-45	
039	ST01	35 01	
040	.	-62	
041	0	00	
042	1	01	
043	9	09	
044	x	-35	
045	10ˣ	16 33	
046	RCL5	36 05	
047	x	-35	
048	INT	16 34	
049	RCL5	36 05	
050	FRC	16 44	
051	+	-55	
052	ST05	35 05	
053	EEX	-23	
054	2	02	
055	÷	-24	
056	PRTX	-14	
057	RTN	24	
058	*LBLE	21 15	
059	RCL1	36 01	
060	3	03	
061	7	07	Calculate pH
062	+	-55	
063	EEX	-23	
064	3	03	
065	÷	-24	
066	RCL6	36 06	
067	RCL1	36 01	
068	1	01	
069	4	04	
070	.	-62	
071	6	06	
072	x	-35	
073	-	-45	
074	INT	16 34	
075	+	-55	
076	ST06	35 06	
077	EEX	-23	
078	3	03	
079	÷	-24	
080	PRTX	-14	
081	RTN	24	
082	R/S	51	
090			
100			
110			

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
	ΔT				$PCO_2 \cdot PO_2$	pH·BT			

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title ANAEROBIC PO_2 CHANGE

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables

This program corrects PO_2, measured at 37°C, to Body Temperature.

Equation Used:

Correction of PO_2 for anaerobic temperature change is calculated taking into account the exchange of oxygen between $HgbO_2$ and the dissolved state at high saturation. Below 80% Sat., the relation is approximately

$$\frac{\Delta \text{ Log } PO_2}{\Delta T} = 0.031$$

This factor falls at higher saturations, approaching 0.006 at 100% Sat. The curve given by Severinghaus has been approximated by the following equation in this program.

$$\frac{\Delta \log PO_2}{\Delta T} = \frac{3130-62.5 \text{ Sat} + 0.312008 \text{ Sat}^2}{100{,}000-1993\text{Sat}+9.9313\text{Sat}^2}$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

Sat. =90%

PO_2 =75 mmHg

BT =40°C

Solution(s)

90 [B] 75[C] 40[D]→92.31mmHg, PO_2(BT)

Reference(s) Severinghaus, John W., "Blood Gas Calculator," J.Appl. Physiol., 21 (3): 1108-1116,1966.

This program is a translation of the HP-65 Users' Library Program #00199A submitted by Hewlett-Packard.

User Instructions

ANAEROBIC PO_2 CHANGE

→RCL SAT	SAT	PO_2 (37°)	BT→PO_2 (BT)	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	If it was previously stored recall SAT		A		SAT(%)
3	Input SAT%	SAT%	B		PO_2(if stored)
4	Input PO_2(37°)	PO_2(mmHg)	C		BT(if stored)
5	Input BT and compute PO_2(BT)	BT(°C)	D		PO_2(mmHg)
	Detailed User Instructions:				
	This program corrects PCO_2 and pH, measured at				
	37°C, to body temperature. It replaces 37°C				
	values in memory with the body temperature				
	values. Therefore, calculation based on the 37°C				
	values in programs for "Blood Acid-Base Status"				
	and "Virtual PO_2" should be accomplished before				
	this program of "Anaerobic PO_2 Change" is run.				
	If PCO_2(37°) was previously stored in memory, it				
	can be recalled by pressing [A]. If not, skip				
	[A] and input PCO_2(37°). Press [B]; if pH				
	(37°) was previously stored, it will appear.				
	If not, input it. Press [C], if body				
	temperature was previously stored, it will				
	appear. If not, input it in °C. Press [D];				
	PCO_2(BT) will appear and be stored in memory.				
	Press [E]; pH(BT) will appear and be stored in				
	memory.				
	This program may also be used to convert PCO_2				
	and pH between any two temperatures, for example,				
	from body temperature to 37°C. To do this,				
	first determine what the desired temperature				
	change is in °C. Add this to 37°C algebraically,				
	and input the result as BT. For example, suppose				
	values known as 41°C are to be converted to				
	37°C. The temperature change is -4°C; this,				
	when added to 37°C, results in 33°C. Executing				
	the program with BT=33° will then result in 37°C				
	values for PCO_2 and pH.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Recall Sat if stored
002	RCL8	36 08	
003	RTN	24	
004	*LBLB	21 12	Enter Sat.
005	STO8	35 08	
006	RCL5	36 05	Display PO_2
007	GSBE	23 15	
008	RTN	24	
009	*LBLC	21 13	Enter PO_2
010	EEX	-23	
011	3	03	Entangle with PCO_2
012	÷	-24	in R_5
013	RCL5	36 05	
014	INT	16 34	
015	+	-55	
016	STO5	35 05	
017	RCL6	36 06	Display BT
018	GSBE	23 15	
019	RTN	24	
020	*LBLD	21 14	Enter BT
021	STO1	35 01	
022	EEX	-23	
023	3	03	
024	÷	-24	
025	RCL6	36 06	
026	INT	16 34	Calculate PO_2
027	+	-55	
028	STO6	35 06	
029	RCL8	36 08	
030	X^2	53	
031	.	-62	
032	3	03	
033	1	01	
034	2	02	
035	0	00	
036	0	00	
037	8	08	
038	x	-35	
039	RCL8	36 08	
040	6	06	
041	2	02	
042	.	-62	
043	5	05	
044	x	-35	
045	-	-45	
046	3	03	
047	1	01	
048	3	03	
049	0	00	
050	+	-55	
051	RCL8	36 08	
052	X^2	53	
053	9	09	
054	.	-62	
055	9	09	
056	3	03	
057	1	01	
058	3	03	
059	x	-35	
060	RCL8	36 08	
061	1	01	
062	9	09	
063	9	09	
064	3	03	
065	x	-35	
066	-	-45	
067	EEX	-23	
068	5	05	
069	+	-55	
070	÷	-24	
071	RCL1	36 01	
072	3	03	
073	7	07	
074	-	-45	
075	x	-35	
076	10^x	16 33	
077	RCL5	36 05	
078	GSBE	23 15	
079	x	-35	
080	GSBC	23 13	
081	RCL5	36 05	
082	GSBE	23 15	
083	PRTX	-14	Display PO_2
084	RTN	24	
085	*LBLE	21 15	Subroutine
086	FRC	16 44	
087	EEX	-23	
088	3	03	
089	x	-35	
090	RTN	24	
091	R/S	51	

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
	BT(°C)				$PCO_2 \cdot PO_2$	pH·BT		SAT.	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title DEAD SPACE FRACTION

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables

This program calculates respiratory exchange ratio, alveolar minute volume, and ratio of dead space to tidal volume.

Equations Used:

Respiratory exchange ratio,

$$R_Q = \frac{VCO_2 \text{ (ml/min STPD)}}{VO_2 \text{ (ml/min STPD)}}$$

Alveolar minute volume,

$$V_A (\ell\text{/min BTPS}) = \frac{0.863\ VCO_2 \text{ (ml/min STPD)}}{P_aCO_2 \text{ (mmHg)}}$$

Ratio of dead space to tidal volume,

$$V_D/V_T = \frac{V_E - V_A \ (\ell\text{/min BTPS})}{V_E (\ell\text{/min BTPS})}$$

These may be found in most standard texts on respiratory gas exchange.

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

VCO_2 =266ml/minSTPD

VO_2 =280ml/min STPD

P_aCO_2=45 mmHg

V_E =7 ℓ/min BTPS

Solution(s) 266 [A] 280[B] →0.95, R_Q

[C]45[D] →5.10ℓ/min, BTPS

7 [E] →0.27,V_D/V_T

or if desired:

280 [B] .95[C]

45 [D] →5.10ℓ/min, BTPS

7 [E] →0.27, V_D/V_T

or, if R_Q is not desired:

266 [A] 45 [D] →5.10ℓ/min, BTPS

7 [E]→ 0.27, V_D/V_T

Reference(s) Otis, A.B., Handbook of Physiology, VOL 1, Sec 3, P.681-698.

This program is a translation of the HP-65 Users' Library Program #00200A submitted by Hewlett-Packard.

User Instructions

DEAD SPACE FRACTION

1					2
$\dot{V}CO_2$	$\dot{V}O_2$	RQ	$P_aCO_2 \rightarrow \dot{V}_A$	$\dot{V}_E \rightarrow \frac{VD}{V_T}$	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input VCO_2	VCO_2 (mil/min)	A		VO_2 (if stored)
3	Input VO_2	VO_2 (ml/min)	B		R_Q
4	Input R_Q if not displayed	R_Q	C		P_aCO_2 (if stored)
5	Input P_aCO_2 and calculate V_A	P_aCO_2 (mmHg)	D		V_A (ℓ/min)
6	Input V_E and calculate V_D/V_T	V_E (ℓ/min)	E		V_D/V_T

Detailed User Instructions:

CO_2 output ($\dot{V}CO_2$) and O_2 uptake ($\dot{V}O_2$) are input in milliliters per minute, STPD. If the experimental values are not measured in STPD, they should be converted prior to input. The HP-67/97 may be used as a four-function calculator between input entries for purposes of unit conversion. If a separate program is to be used for conversion the conversion should be done prior to running this series of programs, as some patient data may be lost from memory.

The values of $\dot{V}CO_2$ and $\dot{V}O_2$ are stored in memory for use by later programs. If $\dot{V}O_2$ has been previously stored by the Fick calculation program, it will be recalled automatically. After R_Q appears, press [C] to store $\dot{V}CO_2$ and $\dot{V}O_2$. PCO_2 will appear if previously stored.

The $\dot{V}_A$ is output (displayed) in liters per minute BTPS. If, after computing $\dot{V}_A$, it is desired to calculate the ventilation/perfusion ratio ($\dot{V}_A/\dot{Q}$), and $\dot{Q}$(CO) is already known, simply enter $\dot{Q}$, press [÷], and the $\dot{V}_A/\dot{Q}$ ratio will be displayed. Input total ventilation, $\dot{V}_E$ in ℓ/min. BTPS. The V_D/V_T ratio will appear. To compute actual dead space, utilize the HP 67/97 as a four-function calculator and either multiply by tidal volume, if known, or enter $\dot{V}_E$ again, divide by respiratory rate to obtain tidal volume, and then press [X] to obtain actual dead space volume.

It is possible to input R_Q and either $\dot{V}CO_2$ or $\dot{V}O_2$, rather than both $\dot{V}CO_2$ and $\dot{V}O_2$. When doing this, press only the button for which data

(con't)

User Instructions

DEAD SPACE FRACTION

$\dot{V}CO_2$	$\dot{V}O_2$	RQ	$P_aCO_2 \to \dot{V}_A$	$\dot{V}_E \to \frac{V_D}{V_T}$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	is being input. For example, input $\dot{V}O_2$, press			
	[B], input R_Q, press [C]. The HP 67/97 will			
	calculate the missing $\dot{V}CO_2$ and store both			
	$\dot{V}CO_2$ and $\dot{V}O_2$.			
	Since $\dot{V}O_2$ is not needed in the calculation			
	of $\dot{V}_A$ and V_D/V_T, it need not be input if R_Q is	not		
	desired. In this case, input $\dot{V}CO_2$, press [A]			
	input P_aCO_2, press [D], input $\dot{V}_E$, press [E].			
	$\dot{V}CO_2$ will not be stored in memory in this case.			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter VCO_2
002	SF0	16 21 00	
003	STO1	35 01	
004	RCL2	36 02	Display stored VO_2
005	RTN	24	
006	*LBLB	21 12	Enter VO_2
007	SF1	16 21 01	
008	STO8	35 08	
009	F0?	16 23 00	
010	GTO0	22 00	If VCO_2 entered calculate R_Q
011	CLX	-51	
012	RTN	24	Else display 0
013	*LBL0	21 00	Calc. of R_Q
014	RCL1	36 01	
015	X⇄Y	-41	
016	÷	-24	
017	PRTX	-14	
018	RTN	24	
019	*LBLC	21 13	Enter R_Q
020	F0?	16 23 00	Was VCO_2 entered
021	GTO0	22 00	Yes
022	GTO1	22 01	No, calc. VCO_2
023	*LBL0	21 00	
024	F1?	16 23 01	Was VO_2 entered
025	GTO2	22 02	Yes, go to 2
026	RCL1	36 01	No, calc. VO_2
027	X⇄Y	-41	
028	÷	-24	
029	STO8	35 08	Save VO_2
030	*LBL2	21 02	
031	RCL1	36 01	
032	EEX	-23	
033	4	04	Entangle VO_2&VCO_2
034	÷	-24	
035	FRC	16 44	
036	RCL8	36 08	
037	INT	16 34	
038	+	-55	
039	STO2	35 02	Store in R_2
040	CF0	16 22 00	
041	CF1	16 22 01	
042	RCL5	36 05	
043	EEX	-23	
044	2	02	
045	÷	-24	
046	RTN	24	Display P_aCO_2
047	*LBLD	21 14	Enter P_aCO_2
048	RCL1	36 01	
049	.	-62	
050	8	08	
051	6	06	
052	3	03	STPD →BTPS
053	×	-35	
054	X⇄Y	-41	
055	÷	-24	Calc. V_A
056	LSTX	16-63	
057	EEX	-23	Entangle P_aCO_2 with PO_2 in R_5
058	2	02	
059	×	-35	
060	INT	16 34	
061	RCL5	36 05	
062	FRC	16 44	
063	+	-55	
064	STO5	35 05	
065	R↓	-31	
066	STO1	35 01	
067	PRTX	-14	Display V_A
068	RTN	24	
069	*LBLE	21 15	Enter V_E
070	ENT↑	-21	
071	ENT↑	-21	
072	RCL1	36 01	Calc. V_D/V_T
073	-	-45	
074	X⇄Y	-41	
075	÷	-24	
076	PRTX	-14	Display V_D/V_T
077	RTN	24	
078	*LBL1	21 01	Calculate VCO_2
079	F1?	16 23 01	Was VO_2 input?
080	GTO0	22 00	Yes, go to 0
081	CLX	-51	No, error
082	÷	-24	
083	RTN	24	
084	*LBL0	21 00	
085	RCL8	36 08	
086	×	-35	
087	STO1	35 01	
088	GTO2	22 02	
089	R/S	51	

FLAGS	
0	$\dot{V}CO_2$?
1	$\dot{V}O_2$?
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
	VCO_2/VA	$VO_2 \cdot VCO_2$			$P_aCO_2 \cdot PO_2$			VO_2	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title ALVEOLAR-ARTERIAL OXYGEN TENSION DIFFERENCE

Contributor's Name Users' Library, Hewlett-Packard Company

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables

This program calculates the difference between alveolar and arterial oxygen concentration. One approximation has been made in the equation for P_AO_2. In the third term, which is a small correction factor, the F_IO_2 has been derived by dividing the P_IO_2 by 760, the nominal barometric pressure at sea level. The error introduced will be negligible unless measurements are being made at a very high altitude and very high inspired oxygen tension.

Equations Used:

$$A\text{-}aO_2 = P_AO_2 - P_aO_2 \text{ (mmHg)}$$

$$P_AO_2 = P_IO_2 - \frac{P_aCO_2}{R_Q} + \frac{P_IO_2}{760} \cdot P_aCO_2 \cdot \frac{1-R_Q}{R_Q} \text{ (mmHg)}$$

where

$$P_IO_2 = \frac{F_IO_2\ (\%)}{100} \cdot P_{Barometer} \text{ (mmHg)}$$

$$R_Q = \frac{VCO_2 \text{ (ml/minSTPD)}}{VO_2 \text{ (ml/min STPD)}}$$

Operating Limits and Warnings

Program Description II

Sketch(es)

Sample Problem(s)

P_1O_2 = 150mmHg

P_aO_2 =100mmHg

P_aCO_2 = 45mmHg

R =0.95

Solution(s)

150 [A] 100 [B] 45[C] .95[D] →3.10 mmHg, A-a diff.
[E] → 103.10 mmHg, P_AO_2

Reference(s) This program is a translation of the HP-65 Users' Library Program #00201A submitted by Hewlett-Packard

West, John B., "Ventilation/Blood Flow and Gas Exchange", 2nd ed., Blackwell Scientific Publication, Oxford, 1970.

User Instructions

A-aO_2 TENSION DIFFERENCE

P_IO_2	P_aO_2	P_aCO_2	RQ→A-a	→P_AO_2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input P_IO_2*	P_IO_2 (mmHg)	A		PO_2 (if stored)
3	Input P_aO_2	P_aO_2 (mmHg)	B		PCO_2 (if stored)
4	Input P_aCO_2	P_aCO_2 (mmHg)	C		R_Q (if stored)
5	Input R_Q and calculate A-a	R_Q	D		A-aO_2 (mmHg)
6	Calculate P_AO_2		E		P_AO_2 (mmHg)

* The stored PO_2 will be recalled. If this is the arterial P_aO_2, simply press [B]. Otherwise, input the value and press [B]. Repeat for PCO_2, using [C]. If CO_2 output and O_2 uptake were previously input, R_Q will be computed and recalled. Otherwise, input R_Q and press [D]. The A-aO_2 difference will now appear on the display. To derive P_AO_2 press [E]. This value is left in the display register and is ready for input into "Virtual PO_2 & O_2 Saturation & Content" if alveolar O_2 content and physiologic shunt are to be calculated.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter P_IO_2
002	STO8	35 08	
003	RCL5	36 05	
004	FRC	16 44	
005	EEX	-23	Untangle PO_2
006	3	03	
007	×	-35	
008	RTN	24	
009	*LBLB	21 12	Enter P_aO_2
010	EEX	-23	
011	3	03	Entangle with PCO_2
012	÷	-24	in PO_2
013	RCL5	36 05	
014	INT	16 34	
015	+	-55	
016	STO5	35 05	
017	EEX	-23	Untangle PCO_2
018	2	02	
019	÷	-24	
020	RTN	24	
021	*LBLC	21 13	Enter P_aCO_2
022	STO1	35 01	
023	EEX	-23	Entangle with P_aO_2
024	2	02	in R_5
025	×	-35	
026	INT	16 34	
027	RCL5	36 05	
028	FRC	16 44	
029	+	-55	
030	STO5	35 05	
031	RCL9	36 09	Save Hgb
032	RCL2	36 02	
033	FRC	16 44	
034	RCL2	36 02	
035	INT	16 34	
036	0	00	
037	X=Y?	16-33	
038	GTO1	22 01	
039	R↓	-31	
040	EEX	-23	Compute R_Q
041	4	04	
042	÷	-24	
043	÷	-24	
044	*LBL1	21 01	Restore Hgb
045	R↑	16-31	
046	STO9	35 09	
047	R↓	-31	Display 0 or R_Q
048	RTN	24	
049	*LBLD	21 14	Enter R_Q
050	RCL1	36 01	Compute P_AO_2
051	CHS	-22	
052	X⇄Y	-41	
053	÷	-24	
054	LSTX	16-63	
055	1/X	52	
056	1	01	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	-	-45	
058	RCL1	36 01	
059	×	-35	
060	RCL8	36 08	
061	7	07	
062	6	06	
063	0	00	
064	÷	-24	
065	×	-35	
066	+	-55	
067	RCL8	36 08	
068	+	-55	
069	STO1	35 01	
070	RCL5	36 05	
071	FRC	16 44	Compute A-a diff.
072	EEX	-23	
073	3	03	
074	×	-35	
075	-	-45	
076	PRTX	-14	
077	RTN	24	
078	*LBLE	21 15	Display P_AO_2
079	RCL1	36 01	
080	PRTX	-14	
081	RTN	24	
082	R/S	51	
090			
100			
110			

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
	P_aCO_2/P_aO_2	USED			USED			P_IO_2	Hgb
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title PHYSIOLOGIC SHUNT AND FICK

Contributor's Name HEWLETT-PACKARD

Address 1000 N.E. Circle Boulevard

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

Program Description, Equations, Variables

The Fick cardiac output and physiologic shunt fraction are calculated from arterial, venous and alveolar oxygen concentration and oxygen intake.

Equations Used:

$$CO(\ell/min) = \frac{VO_2 \ (ml/minSTPD) \cdot 100(\%)}{(C_aO_2 - C_VO_2 \ (vol.\%) \cdot 1000 \ (ml/\ell)}$$

$$Phys.\ Shunt = \frac{C_AO_2 - C_aO_2}{C_AO_2 - C_VO_2}$$

These are the standard Fick cardiac output and physiologic shunt equations. If measured O_2 saturations are used, these equations will be accurate.

Operating Limits and Warnings

If the content values have been derived from saturation estimates on PO_2 measurements for arterial and venous blood, the results should be viewed with caution unless the patients oxygen dissociation curve has been established to be normal.

Program Description II

Sketch(es)

Sample Problem(s)

C_AO_2 = 20 vol.%

C_aO_2 = 18 vol.%

$C_{\bar{v}}O_2$ = 15 vol.%

$\dot{V}O_2$ = 250 ml/min. STPD

Solution(s)

20 [A] 18 [B] 15[C] 250 [D] → 8.33 ℓ/min (CO)

[E] → 40.00% (SHUNT)

Reference(s) This program is a translation of the HP-65 Users' Library Program #00202A submitted by Hewlett-Packard.

Comroe, Julius H., Jr.,et al. The Lung, 2nd ed., Year Book Medical Publishers, Inc. Chicago, 1962, p.345. Yang, Sing San, et al, From Cardiac Catheterization Data to Hemodynamic Parameters, F.A.Davis Co., Phil., 1972, p.21.

User Instructions

PHYSIOLOGIC SHUNT AND FICK

1 | C_AO_2 | C_aO_2 | C_vO_2 | $VO_2 \rightarrow CO$ | → SHUNT | 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input C_AO_2	C_AO_2 (Vol.%)	A		C_aO_2 (if stored)
3	Input C_aO_2	C_aO_2 (Vol.%)	B		C_vO_2 (if stored)
4	Input C_vO_2	C_vO_2 (Vol.%)	C		VO_2 (if stored)
5	Input VO_2 and calculate CO	VO_2 (ml/min)	D		CO (ℓ/min)
6	Calculate shunt %				

Detailed User Instructions:

If arterial and venous O_2 contents have been previously calculated and stored, and if "Virtual PO_2 & O_2 Saturation" has been used immediately previous to calculate equivalent alveolar content then it will not be necessary to re-enter any content values. The C_AO_2 will be in the display register ready for entry. If the values are not stored, they may simply be entered. The $\dot{V}O_2$, osygen uptake, will be recalled if previously entered. If not, it should be entered in ml/min. STPD. The Fick cardiac output results from pressing [D]. Pressing [E] will cause the physiologic blood shunt to be displayed, expressed as a percent.

After cardiac output is calculated, stroke volume may be calculated by heart rate and multiplying by 1000 (to convert from 1 to ml). Alternatively, cardiac index may be calculated by dividing by body surface area.

If the program is to be used to calculate output only, it is not necessary to input C_AO_2. However, [A] should be pressed to start the program anyway.

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Enter C_AO_2
002	STO1	35 01	
003	RCL4	36 04	Display C_AO_2
004	RTN	24	
005	*LBLB	21 12	Enter C_AO_2
006	STO4	35 04	
007	RCL3	36 03	Display C_VO_2
008	RTN	24	
009	*LBLC	21 13	Enter C_VO_2
010	STO3	35 03	
011	RCL2	36 02	Display VO_2
012	RTN	24	
013	*LBLD	21 14	Enter VO_2
014	INT	16 34	
015	RCL2	36 02	
016	FRC	16 44	
017	+	-55	
018	STO2	35 02	
019	RCL4	36 04	
020	RCL3	36 03	
021	-	-45	
022	÷	-24	
023	1	01	
024	0	00	
025	÷	-24	
026	STO8	35 08	
027	EEX	-23	
028	2	02	
029	×	-35	
030	INT	16 34	
031	RCL7	36 07	
032	FRC	16 44	
033	+	-55	
034	STO7	35 07	Display CO
035	RCL8	36 08	
036	PRTX	-14	
037	RTN	24	
038	*LBLE	21 15	Compute shunt
039	RCL1	36 01	
040	RCL4	36 04	
041	-	-45	
042	RCL1	36 01	
043	RCL3	36 03	
044	-	-45	
045	÷	-24	
046	EEX	-23	
047	2	02	
048	×	-35	
049	PRTX	-14	
050	RTN	24	
051	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
	C_AO_2	USED	C_VO_2	C_aO_2			USED	CO	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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:

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

$$\text{CI} = \frac{\text{CO(1/min)}}{\text{BSA } (m^2)}$$

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	×	-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	×	-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

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	.	-62	
058	3	03	
059	Y^x	31	
060	RCL6	36 06	
061	EEX	-23	
062	3	03	
063	×	-35	
064	ENT↑	-21	
065	LOG	16 32	
066	.	-62	
067	0	00	
068	1	01	
069	8	08	
070	8	08	
071	×	-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	×	-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	

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
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

NOTES

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