SECTION 5
PERFORMANCE

TABLE OF CONTENTS

	Page
Introduction	5-3
Use of Performance Charts	5-3
Sample Problem	5-3
Takeoff	5-4
Cruise	5-5
Fuel Required	5-6
Landing	5-7
Figure 5-1, Airspeed Calibration - Normal Static Source	5-8
Airspeed Calibration - Alternate Static Source	5-9
Figure 5-2, Temperature Conversion Chart	5-10
Figure 5-3, Stall Speeds	5-11
Figure 5-4, Takeoff Distance - 2300 Lbs	5-12
Takeoff Distance - 2100 Lbs and 1900 Lbs	5-13
Figure 5-5, Rate of Climb	5-14
Figure 5-6, Time, Fuel, and Distance to Climb	5-15
Figure 5-7, Cruise Performance	5-16
Figure 5-8, Range Profile - 38.0 Gallons Fuel	5-17
Range Profile - 48.0 Gallons Fuel	5-18
Figure 5-9, Endurance Profile - 38.0 Gallons Fuel	5-19
Endurance Profile - 48.0 Gallons Fuel	5-20
Figure 5-10, Landing Distance	5-21

INTRODUCTION

Performance data charts on the following pages are presented so that you may know what to expect from the airplane under various conditions, and also, to facilitate the planning of flights in detail and with reasonable accuracy. The data in the charts has been computed from actual flight tests with the airplane and engine in good condition and using average piloting techniques.

It should be noted that the performance information presented in the range and endurance profile charts allows for 45 minutes reserve fuel based on 45% power. Fuel flow data for cruise is based on the recommended lean mixture setting. Some indeterminate variables such as mixture leaning technique, fuel metering characteristics, engine and propeller condition, and air turbulence may account for variations of 10% or more in range and endurance. Therefore, it is important to utilize all available information to estimate the fuel required for the particular flight.

USE OF PERFORMANCE CHARTS

Performance data is presented in tabular or graphical form to illustrate the effect of different variables. Sufficiently detailed information is provided in the tables so that conservative values can be selected and used to determine the particular performance figure with reasonable accuracy.

SAMPLE PROBLEM

The following sample flight problem utilizes information from the various charts to determine the predicted performance data for a typical flight. The following information is known:

AIRPLANE CONFIGURATION	
Takeoff weight	2250 Pounds
Usable fuel	38 Gallons
TAKEOFF CONDITIONS	
Field pressure altitude	1500 Feet
Temperature	28°C (16°C above standard)
Wind component along runway	12 Knot Headwind
Field length	3500 Feet

CRUISE CONDITIONS	
Total distance	420 Nautical Miles
Pressure altitude	5500 Feet
Temperature	20°C (16°C above standard)
Expected wind enroute	10 Knot Headwind
LANDING CONDITIONS	
Field pressure altitude	2000 Feet
Temperature	25°C
Wind component along runway	6 Knot Headwind
Field length	3000 Feet

TAKEOFF

The takeoff distance chart, figure 5-4, should be consulted, keeping in mind that the distances shown are based on maximum performance techniques. Conservative distances can be established by reading the chart at the next higher value of weight, altitude and temperature. For example, in this particular sample problem, the takeoff distance information presented for a weight of 2300 lbs., a pressure altitude of 2000 feet and a temperature of 30°C should be used and results in the following:

Ground roll	1155 Feet
Total distance to clear a 50-foot obstacle	2030 Feet

A correction for the effect of wind may be made based on Note 3 of the takeoff chart. The distance correction for a 12 knot headwind is:

$$\frac{12 \text{ Knots}}{9 \text{ Knots}} \times 10\% = 13\% \text{ Decrease}$$

This results in the following distances, corrected for wind:

Ground roll, zero wind	1155
Decrease in ground roll (1155 feet x 13%)	150
Corrected ground roll	1005 Feet
Total distance to clear a 50-foot obstacle, zero wind	2030
Decrease in total distance (2030 feet x 13%)	264
Corrected total distance to clear 50-foot obstacle	1766 Feet

These distances are well within the takeoff field length quoted earlier for

the sample problem.

CRUISE

The cruising altitude and winds aloft information have been given for this flight. However, the power setting selection for cruise must be determined based on several considerations. These include the cruise performance characteristics of the airplane presented in figure 5-7, the range profile chart presented in figure 5-8, and the endurance profile chart presented in figure 5-9.

The range profile chart illustrates the relationship between power and range. Considerable fuel savings and longer range result when lower power settings are used.

For this sample problem with a cruise altitude of 5500 feet and distance of 420 nautical miles, the range profile chart indicates that use of a 75% power setting will necessitate a fuel stop, in view of the anticipated 10 knot headwind component. However, selecting a 65% power setting from the range profile chart yields a predicted range of 477 nautical miles under zero wind conditions. The endurance profile chart, figure 5-9, shows a corresponding 4.4 hours.

The range figure of 477 nautical miles is corrected to account for the expected 10 knot headwind at 5500 feet.

Range, zero wind	477
Decrease in range due to wind (4.4 hours x 10 knot headwind)	44
Corrected range	433 Nautical Miles

This indicates that the trip can be made without a fuel stop using approximately 65% power.

The cruise performance chart, figure 5-7, is entered at 6000 feet altitude and 20°C above standard temperature. These values most nearly correspond to the expected altitude and temperature conditions. The engine speed chosen is 2500 RPM, which results in the following:

Power	62%
True airspeed	109 Knots
Cruise fuel flow	7.0 GPH

The power computer may be used to determine power and fuel consumption during the flight.

FUEL REQUIRED

The total fuel requirement for the flight may be estimated using the performance information in figures 5-6 and 5-7. For this sample problem, figure 5-6 shows that a climb from 1000 feet to 6000 feet requires 2.0 gallons of fuel and may be used as a conservative estimate for this problem. This is for a standard temperature (as shown on the climb chart). The approximate effect of a non-standard temperature is to increase the time, fuel, and distance by 10% for each 10°C above standard temperature, due to the lower rate of climb. In this case, assuming a temperature 16°C above standard, the correction would be:

$$\frac{16^\circ C}{10^\circ C} \times 10\% = 16\% \text{ Increase}$$

With this factor included, the fuel estimate would be calculated as follows:

Fuel to climb, standard temperature	2.0
Increase due to non-standard temperature (2.0 x 16%)	0.3
Corrected fuel to climb	2.3 Gallons

In addition, the distance to climb, as given in figure 5-6, may be corrected for non-standard temperature as follows:

Distance to climb, standard temperature	14
Increase due to non-standard temperature (14 nautical miles x 16%)	2
Corrected distance to climb	16 Nautical Miles

The resultant cruise distance is:

Total distance	420
Climb distance	-16
Cruise distance	404 Nautical Miles

With an expected 10 knot headwind, the ground speed for cruise is predicted to be:

109
-10
99 Knots

Therefore, the time required for the cruise portion of the trip is:

$$\frac{404 \text{ Nautical Miles}}{99 \text{ Knots}} = 4.1 \text{ Hours}$$

The fuel required for cruise is endurance times fuel consumption:

4.1 hours x 7.0 gallons/hour = 28.7 Gallons

The total estimated fuel required is as follows:

Engine start, taxi, and takeoff	1.1
Climb	2.3
Cruise	28.7
Total fuel required	32.1 Gallons

This will leave a fuel reserve of:

38.0
-32.1
5.9 Gallons

Once the flight is underway, ground speed checks will provide a more accurate basis for estimating the time enroute and the corresponding fuel required to complete the trip with ample reserve.

LANDING

A procedure similar to the takeoff calculations should be used for estimating the landing distance at the destination airport. Figure 5-10 presents maximum performance technique landing distances for various airport altitude and temperature combinations. The distances corresponding to 2000 feet altitude and 30°C should be used and result in the following:

Ground roll	590 Feet
Total distance to clear a 50-foot obstacle	1370 Feet

A correction for wind may be made based on Note 2 of the landing chart. The distance correction for a 6 knot headwind is:

$$\frac{6 \text{ Knots}}{9 \text{ Knots}} \times 10\% = 7\% \text{ Decrease}$$

This results in the following wind-corrected figures:

Ground roll	549 Feet
Total distance over a 50-foot obstacle	1274 Feet

These distances are well within the landing field length quoted previously for this sample problem.

AIRSPEED CALIBRATION

NORMAL STATIC SOURCE

FLAPS UP											
KIAS	40	50	60	70	80	90	100	110	120	130	140
KCAS	49	55	62	70	80	89	99	108	118	128	138
FLAPS 10°											
KIAS	40	50	60	70	80	85	---	---	---	---	---
KCAS	49	55	62	71	80	85	---	---	---	---	---
FLAPS 40°											
KIAS	40	50	60	70	80	85	---	---	---	---	---
KCAS	47	54	62	71	81	86	---	---	---	---	---

Figure 5-1. Airspeed Calibration (Sheet 1 of 2)

AIRSPEED CALIBRATION

ALTERNATE STATIC SOURCE

HEATER/VENTS AND WINDOWS CLOSED

FLAPS UP											
NORMAL KIAS	40	50	60	70	80	90	100	110	120	130	140
ALTERNATE KIAS	39	51	61	71	82	91	101	111	121	131	141
FLAPS 10°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	40	51	61	71	81	85	---	---	---	---	---
FLAPS 40°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	38	50	60	70	79	83	---	---	---	---	---

HEATER/VENTS OPEN AND WINDOWS CLOSED

FLAPS UP											
NORMAL KIAS	40	50	60	70	80	90	100	110	120	130	140
ALTERNATE KIAS	36	48	59	70	80	89	99	108	118	128	139
FLAPS 10°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	38	49	59	69	79	84	---	---	---	---	---
FLAPS 40°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	34	47	57	67	77	81	---	---	---	---	---

WINDOWS OPEN

FLAPS UP											
NORMAL KIAS	40	50	60	70	80	90	100	110	120	130	140
ALTERNATE KIAS	26	43	57	70	82	93	103	113	123	133	143
FLAPS 10°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	25	43	57	69	80	85	---	---	---	---	---
FLAPS 40°											
NORMAL KIAS	40	50	60	70	80	85	---	---	---	---	---
ALTERNATE KIAS	25	41	54	67	78	84	---	---	---	---	---

Figure 5-1. Airspeed Calibration (Sheet 2 of 2)

TEMPERATURE CONVERSION CHART

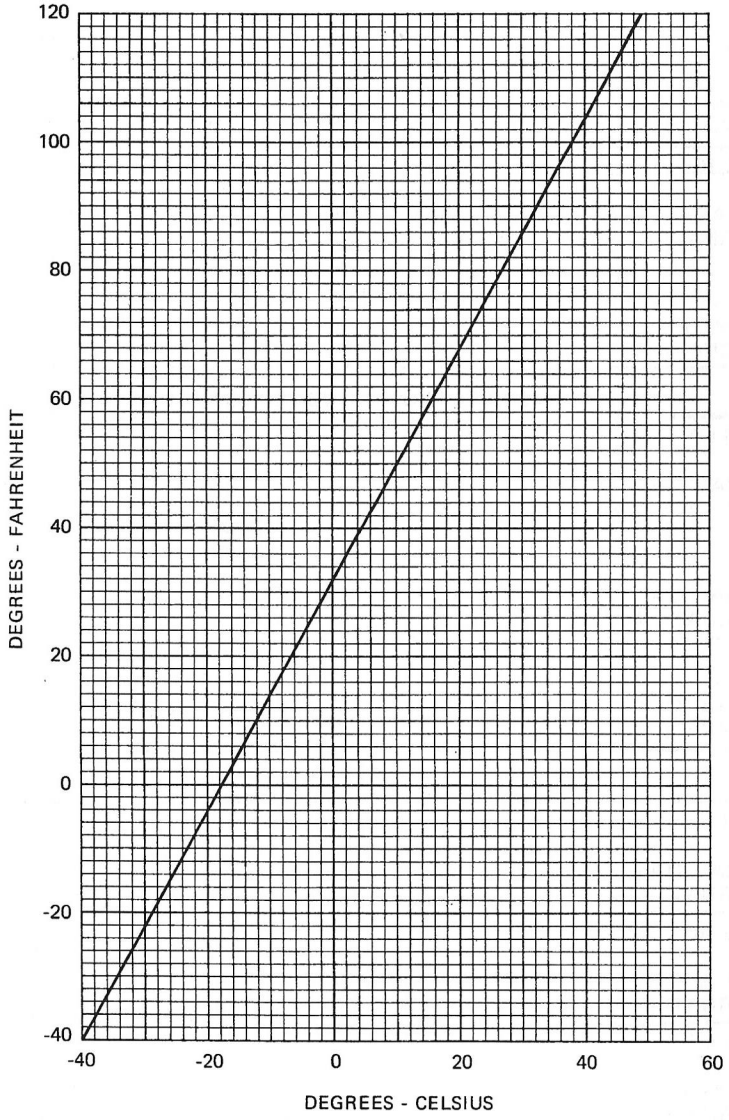

Figure 5-2. Temperature Conversion Chart

STALL SPEEDS

CONDITIONS:
Power Off

NOTES:
1. Maximum altitude loss during a stall recovery is approximately 180 feet.
2. KIAS values are approximate.

MOST REARWARD CENTER OF GRAVITY

WEIGHT LBS	FLAP DEFLECTION	ANGLE OF BANK							
		0°		30°		45°		60°	
		KIAS	KCAS	KIAS	KCAS	KIAS	KCAS	KIAS	KCAS
2300	UP	42	50	45	54	50	59	59	71
	10°	38	47	40	51	45	56	54	66
	40°	36	44	38	47	43	52	51	62

MOST FORWARD CENTER OF GRAVITY

WEIGHT LBS	FLAP DEFLECTION	ANGLE OF BANK							
		0°		30°		45°		60°	
		KIAS	KCAS	KIAS	KCAS	KIAS	KCAS	KIAS	KCAS
2300	UP	47	53	51	57	56	63	66	75
	10°	44	51	47	55	52	61	62	72
	40°	41	47	44	51	49	56	58	66

Figure 5-3. Stall Speeds

TAKEOFF DISTANCE
MAXIMUM WEIGHT 2300 LBS

CONDITIONS:
Flaps Up
Full Throttle Prior to Brake Release
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Maximum performance technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. Where distance value has been deleted, climb performance after lift-off is less than 150 fpm at takeoff speed.
5. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.

WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
2300	52	59	S.L.	775	1380	835	1475	895	1575	960	1685	1030	1795
			1000	850	1510	915	1615	980	1725	1050	1845	1125	1970
			2000	930	1650	1000	1770	1075	1895	1155	2030	1235	2170
			3000	1020	1815	1100	1945	1180	2085	1270	2235	1360	2395
			4000	1125	2000	1210	2145	1300	2305	1395	2475	1495	2655
			5000	1235	2210	1330	2375	1430	2555	1540	2750	1650	2960
			6000	1365	2450	1470	2640	1580	2850	1700	3070	- - -	- - -
			7000	1505	2730	1625	2955	1750	3190	- - -	- - -	- - -	- - -
			8000	1665	3065	1800	3320	- - -	- - -	- - -	- - -	- - -	- - -

Figure 5-4. Takeoff Distance (Sheet 1 of 2)

TAKEOFF DISTANCE
2100 LBS AND 1900 LBS

REFER TO SHEET 1 FOR APPROPRIATE CONDITIONS AND NOTES.

WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
2100	50	56	S.L.	630	1130	680	1210	725	1290	780	1375	835	1465
			1000	690	1235	740	1320	795	1405	855	1500	915	1600
			2000	755	1350	810	1440	870	1540	935	1645	1000	1755
			3000	830	1475	890	1580	955	1690	1025	1805	1100	1930
			4000	910	1620	980	1735	1050	1860	1125	1990	1210	2130
			5000	1000	1780	1075	1910	1155	2050	1240	2195	1330	2355
			6000	1100	1965	1185	2115	1275	2270	1370	2435	1465	2615
			7000	1215	2180	1305	2345	1405	2520	1510	2715	1620	2920
			8000	1340	2425	1445	2615	1555	2815	1675	3040	1795	3280
1900	47	54	S.L.	505	915	540	975	580	1035	620	1105	665	1175
			1000	550	995	590	1060	635	1130	680	1205	725	1280
			2000	600	1085	645	1155	695	1230	745	1315	795	1400
			3000	660	1180	710	1260	760	1345	815	1435	870	1530
			4000	725	1290	775	1380	835	1475	895	1575	955	1680
			5000	795	1415	855	1515	915	1620	985	1735	1055	1850
			6000	870	1555	940	1670	1010	1785	1080	1910	1160	2045
			7000	960	1715	1035	1840	1110	1975	1195	2115	1280	2265
			8000	1060	1900	1140	2040	1225	2190	1320	2350	1415	2520

Figure 5-4. Takeoff Distance (Sheet 2 of 2)

RATE OF CLIMB

CONDITIONS:
Flaps Up
Full Throttle
Mixture Leaned for Maximum RPM During Climb

WEIGHT LBS	PRESS ALT FT	CLIMB SPEED KIAS	RATE OF CLIMB - FPM			
			-20°C	0°C	20°C	40°C
2300	S.L.	78	755	695	630	565
	2000	76	655	595	535	470
	4000	74	555	500	440	380
	6000	72	460	405	350	290
	8000	70	365	310	255	200
	10,000	68	270	215	165	- - -
	12,000	66	175	125	- - -	- - -

Figure 5-5. Rate of Climb

TIME, FUEL, AND DISTANCE TO CLIMB

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

NOTES:
1. Add 1.1 gallons of fuel for engine start, taxi and takeoff allowance.
2. To obtain maximum rate of climb as shown in this chart, lean to maximum RPM during climb.
3. Increase time, fuel and distance by 10% for each 10°C above standard temperature.
4. Distances shown are based on zero wind.

WEIGHT LBS	PRESSURE ALTITUDE FT	TEMP °C	CLIMB SPEED KIAS	RATE OF CLIMB FPM	FROM SEA LEVEL		
					TIME MIN	FUEL USED GALLONS	DISTANCE NM
2300	S.L.	15	78	645	0	0.0	0
	1000	13	77	605	2	0.3	2
	2000	11	76	560	3	0.7	4
	3000	9	75	520	5	1.1	7
	4000	7	74	480	7	1.5	9
	5000	5	73	435	9	1.9	12
	6000	3	72	395	12	2.3	16
	7000	1	71	355	15	2.8	19
	8000	-1	70	315	18	3.3	23
	9000	-3	69	270	21	3.9	28
	10,000	-5	68	230	25	4.5	33
	11,000	-7	67	185	30	5.2	40
	12,000	-9	66	145	36	6.1	48

Figure 5-6. Time, Fuel, and Distance to Climb

CRUISE PERFORMANCE

CONDITIONS:
Recommended Lean Mixture
2300 Pounds

PRESSURE ALTITUDE	RPM	20°C BELOW STANDARD TEMP			STANDARD TEMPERATURE			20°C ABOVE STANDARD TEMP		
		% BHP	KTAS	GPH	% BHP	KTAS	GPH	% BHP	KTAS	GPH
2000	2550	80	114	8.8	75	113	8.2	71	113	7.8
	2500	76	111	8.3	71	111	7.8	67	111	7.5
	2400	68	107	7.5	64	107	7.2	61	106	6.9
	2300	61	102	6.9	58	101	6.7	55	99	6.5
	2200	55	96	6.4	52	95	6.2	49	93	6.1
4000	2600	80	116	8.8	75	116	8.3	71	116	7.8
	2500	72	111	7.9	68	111	7.5	64	110	7.2
	2400	65	107	7.3	61	106	6.9	58	104	6.7
	2300	58	101	6.7	55	100	6.5	53	98	6.3
	2200	52	95	6.3	49	93	6.1	47	92	5.9
6000	2650	80	118	8.8	75	118	8.2	71	118	7.8
	2600	76	116	8.3	71	116	7.9	68	115	7.5
	2500	69	111	7.6	65	110	7.2	62	109	7.0
	2400	62	106	7.0	59	104	6.7	56	103	6.5
	2300	56	100	6.5	53	98	6.3	50	97	6.1
	2200	50	94	6.1	47	92	5.9	45	91	5.8
8000	2700	80	120	8.8	75	120	8.3	71	120	7.8
	2600	72	116	8.0	68	115	7.5	65	114	7.3
	2500	65	111	7.3	62	109	7.0	59	108	6.8
	2400	59	105	6.8	56	103	6.6	53	101	6.3
	2300	54	99	6.4	51	97	6.2	48	96	6.0
	2200	48	93	6.0	45	91	5.8	43	90	5.7
10,000	2700	76	120	8.4	72	120	7.9	68	119	7.6
	2600	69	115	7.6	65	114	7.3	62	112	7.0
	2500	63	110	7.1	59	108	6.8	56	106	6.6
	2400	57	104	6.6	54	102	6.4	51	100	6.2
	2300	51	97	6.2	48	96	6.0	46	95	5.8
	2200	46	92	5.8	43	90	5.7	41	89	5.5
12,000	2650	69	117	7.6	65	116	7.3	62	114	7.0
	2600	66	114	7.4	62	113	7.0	59	111	6.8
	2500	60	108	6.8	57	106	6.6	54	105	6.4
	2400	54	102	6.4	51	100	6.2	49	99	6.0
	2300	49	96	6.0	46	95	5.9	43	94	5.7
	2200	44	91	5.7	41	89	5.5	38	88	5.3

Figure 5-7. Cruise Performance

RANGE PROFILE
45 MINUTES RESERVE
38.0 GALLONS USABLE FUEL

CONDITIONS:
2300 Pounds
Recommended Lean Mixture for Cruise
Standard Temperature
Zero Wind

NOTES:
1. This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the distance during climb as shown in figure 5-6.
2. Reserve fuel is based on 45 minutes at 45% BHP and is 4.3 gallons.

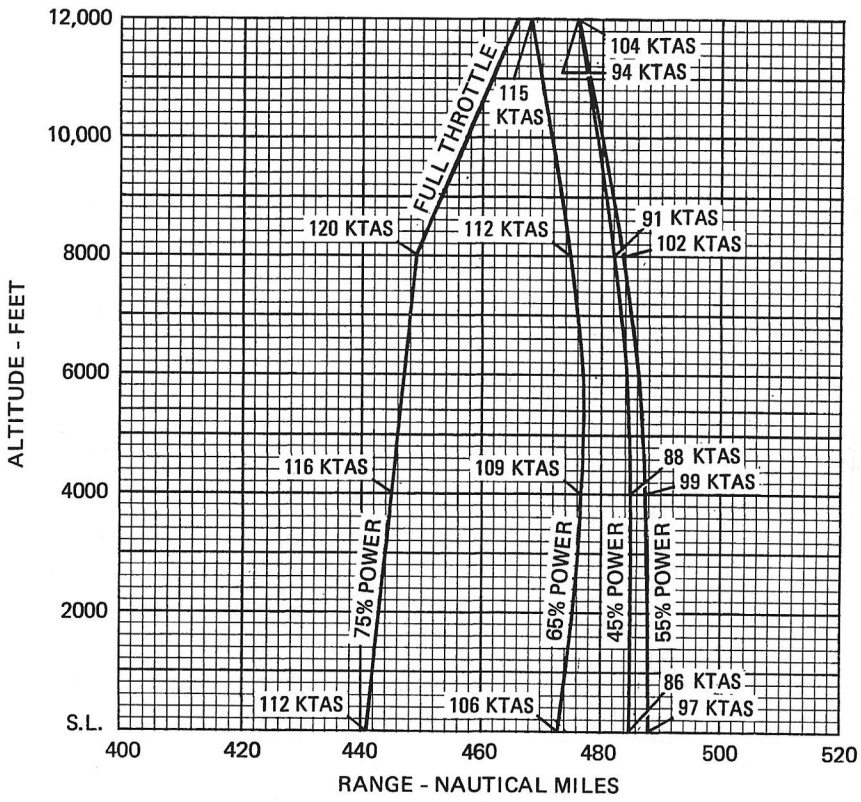

Figure 5-8. Range Profile (Sheet 1 of 2)

RANGE PROFILE
45 MINUTES RESERVE
48.0 GALLONS USABLE FUEL

CONDITIONS:
2300 Pounds
Recommended Lean Mixture for Cruise
Standard Temperature
Zero Wind

NOTES:
1. This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the distance during climb as shown in figure 5-6.
2. Reserve fuel is based on 45 minutes at 45% BHP and is 4.3 gallons.

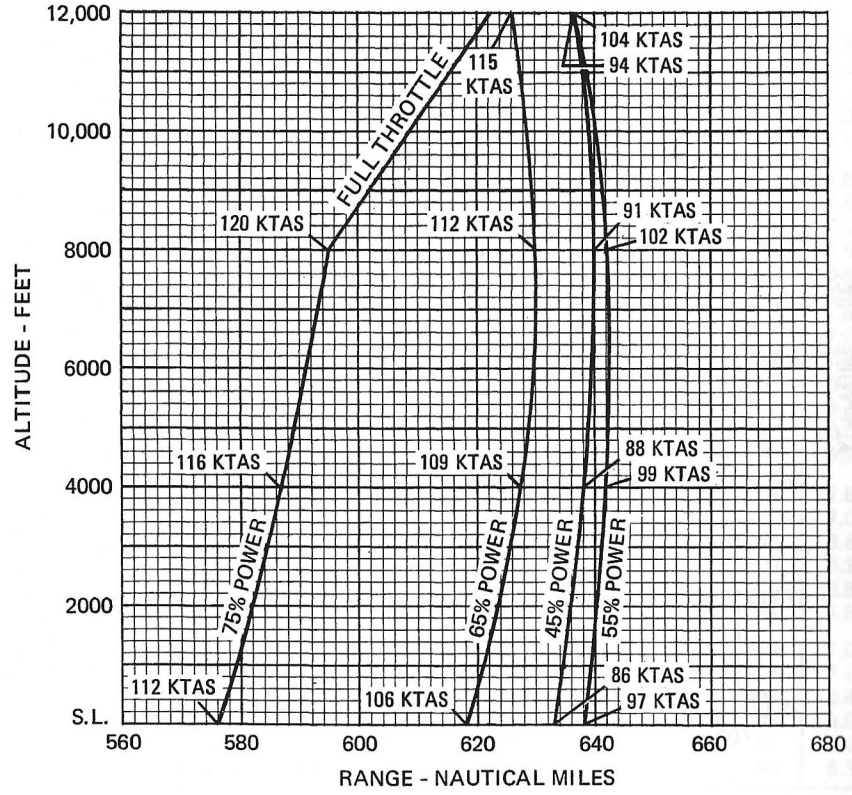

Figure 5-8. Range Profile (Sheet 2 of 2)

ENDURANCE PROFILE
45 MINUTES RESERVE
38.0 GALLONS USABLE FUEL

CONDITIONS:
2300 Pounds
Recommended Lean Mixture for Cruise
Standard Temperature

NOTES:
1. This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the time during climb as shown in figure 5-6.
2. Reserve fuel is based on 45 minutes at 45% BHP and is 4.3 gallons.

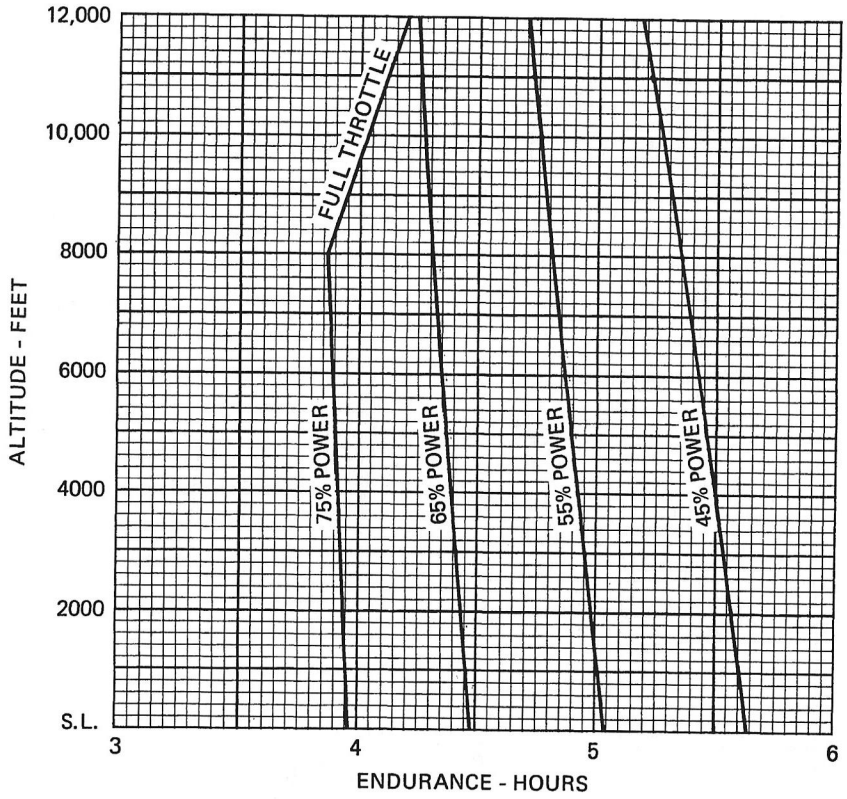

Figure 5-9. Endurance Profile (Sheet 1 of 2)

ENDURANCE PROFILE
45 MINUTES RESERVE
48.0 GALLONS USABLE FUEL

CONDITIONS:
2300 Pounds
Recommended Lean Mixture for Cruise
Standard Temperature

NOTES:
1. This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the time during climb as shown in figure 5-6.
2. Reserve fuel is based on 45 minutes at 45% BHP and is 4.3 gallons.

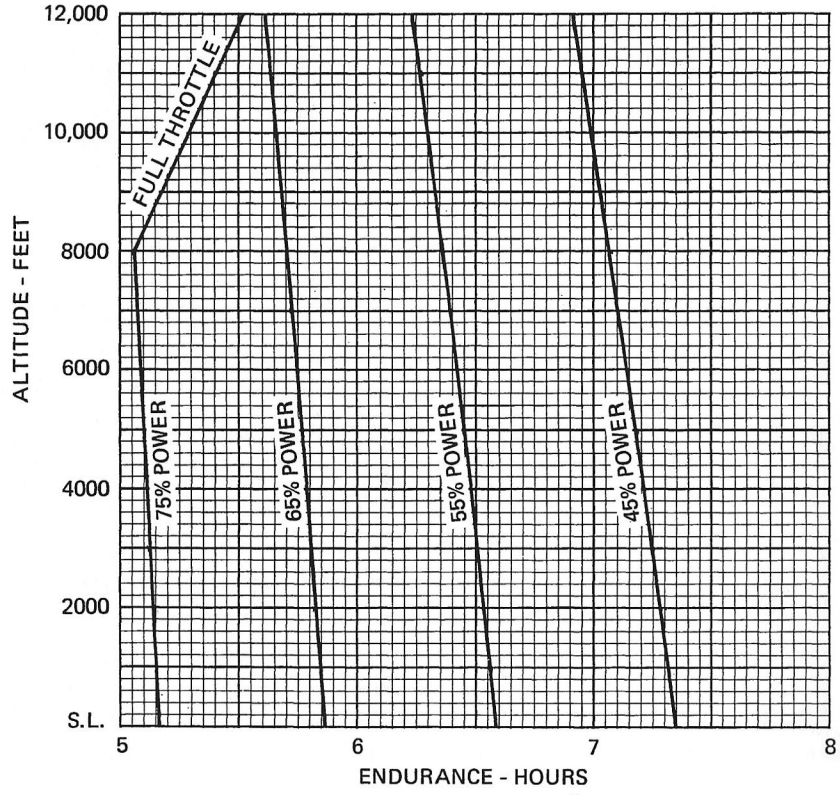

Figure 5-9. Endurance Profile (Sheet 2 of 2)

LANDING DISTANCE

CONDITIONS:
Flaps 40°
Power Off
Maximum Braking
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Maximum performance technique as specified in Section 4.
2. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
3. For operation on a dry, grass runway, increase distances by 45% of the "ground roll" figure.

WEIGHT LBS	SPEED AT 50 FT KIAS	PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
			GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
2300	60	S.L.	495	1205	510	1235	530	1265	545	1295	565	1330
		1000	510	1235	530	1265	550	1300	565	1330	585	1365
		2000	530	1265	550	1300	570	1335	590	1370	610	1405
		3000	550	1300	570	1335	590	1370	610	1405	630	1440
		4000	570	1335	590	1370	615	1410	635	1445	655	1480
		5000	590	1370	615	1415	635	1450	655	1485	680	1525
		6000	615	1415	640	1455	660	1490	685	1535	705	1570
		7000	640	1455	660	1495	685	1535	710	1575	730	1615
		8000	665	1500	690	1540	710	1580	735	1620	760	1665

Figure 5-10. Landing Distance