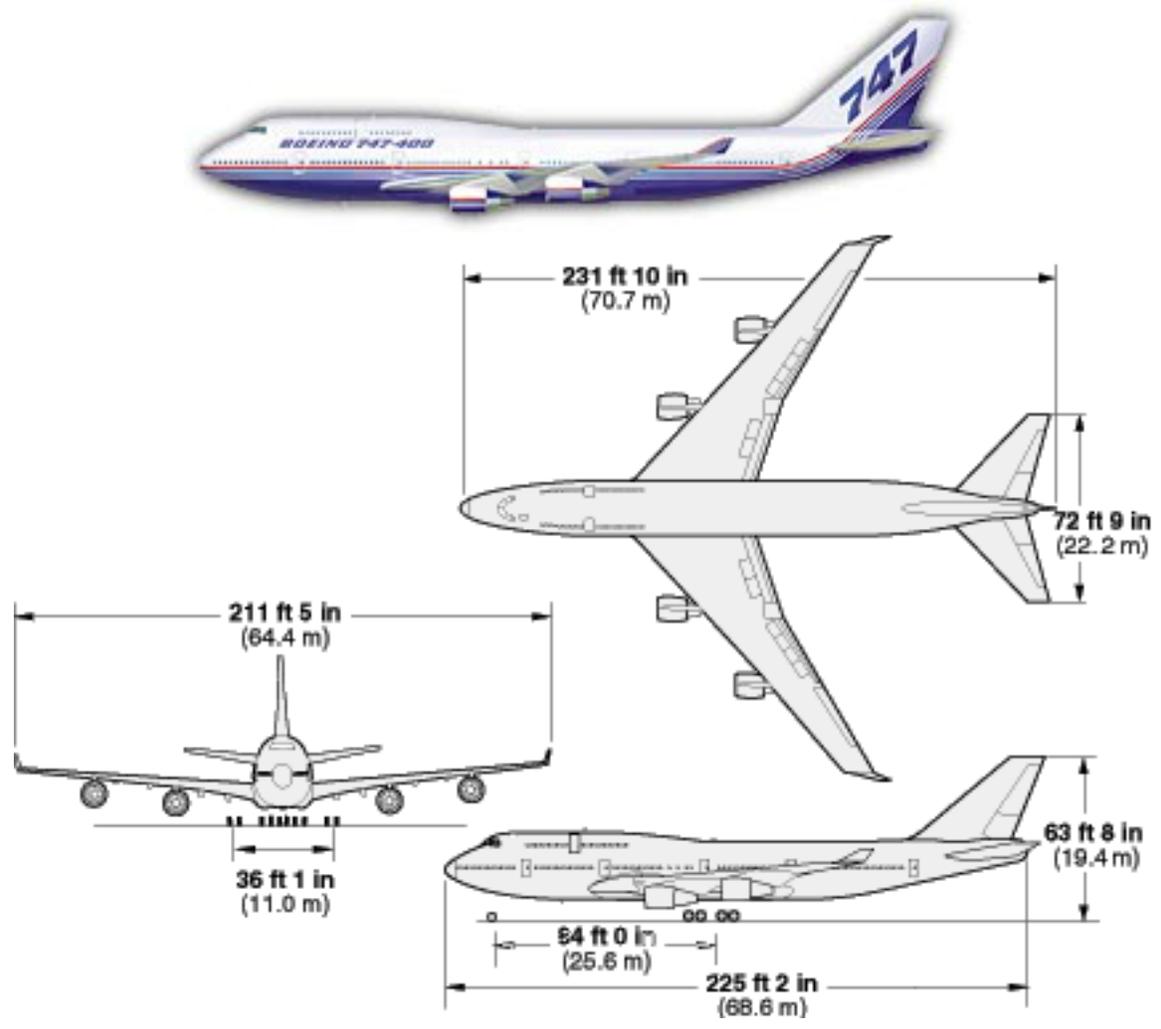


747-400 PILOT OPERATION HANDBOOK

For use with X-Plane flight simulator only

by Mohammed Gazzawi & Sergio Santagada



Passengers	Typical 3-class configuration	416
Passengers	Typical 2-class configuration	524
Cargo*		6,025 ft ³ (170.5 m ³) or 5,332 ft ³ (151 m ³)
Engines		Pratt & Whitney PW4062
maximum thrust		63,300 lb (28,710 kg)
		Rolls-Royce RB211-524H
		59,500 lb (26,990 kg)
		General Electric CF6-80C2B5F
		62,100 lb (27,945 kg)
Maximum Fuel Capacity		57,285 U.S. gal (216,840 L)
Maximum Takeoff Weight		875,000 lb (396,890 kg)
Maximum Range		8,430 statute miles (13,570 km) Typical city pairs: Los Angeles-Hong Kong, Los Angeles-Sydney, Singapore-London
Typical Cruise Speed at 35,000 feet		0.85 Mach - 565 mph (910 km/h)
Basic Dimensions	Wing Span	211 ft 5 in (64.4 m)
	Overall Length	231 ft 10 in (70.6 m)
	Tail Height	63 ft 8 in (19.4 m)
	Interior Cabin Width	20 ft (6.1 m)

*6,025 ft³ (170.5 m³) = 30 LD-1 containers; 5,332 ft³ (151 m³) = 5 pallets, 14 LD-1 containers + bulk (one pallet = 96 in x 125 in/244 cm x 318 cm)

Brief Description of the 747-400

The 747-400 is the latest derivative of the 747 family of airplanes. The -400 is externally similar to the 747-300, with the additional wingtip extension with winglets and advanced high bypass ratio engines. Other characteristics unique to the 747-400 include:

- Two-crew cockpit with digital avionics
- Lightweight aluminum alloys
- Structural carbon brakes
- Optional 875,000-pound maximum takeoff weight
- Optional 3,300-gallon fuel tank in horizontal stabilizer
- Vacuum lavatories with single-point servicing
- Enhanced passenger appeal in cabin interior
- Optional crew rest compartment in aft cabin
- Fly-by-wire system

747-400

The basic 747-400 has a tri-class passenger interior arrangement. Optional arrangements include a two-class or a one-class configuration to suit traffic demands.

747-400 Domestic

The 747-400D is a high-capacity airplane designed for domestic short routes. It has a lighter maximum takeoff weight. The -400D airplane has the same wingspan planform as the -300 and has no winglets.

747-400 Combi

The Combi airplane has a main deck cargo door installed on the left side aft of the wing. This door is used for loading pallets or containerized cargo up to 20 feet long. The main deck of the Combi airplane can be converted to either an all-passenger or a passenger/cargo configuration. In the latter configuration, cargo is in the aft fuselage. Several cargo configurations can be loaded compatible with size limits and operational procedures. The Combi can load up to seven 10-foot pallets or containers.

747-400 Freighter

The 747-400F freighter has a main deck nose door and a mechanized cargo handling system. The nose door swings up so that pallets or containers up to 40 ft (12 m) can be loaded straight in on motor-driven rollers. An optional main deck side cargo door (like the 747-400 Combi) allows loading of dimensionally taller cargo modules.

Definitions

Maximum Design Taxi Weight (MTW). Maximum weight for ground maneuver as limited by aircraft strength and airworthiness requirements. (It includes weight of taxi and run-up fuel.)

Maximum Design Landing Weight (MLW). Maximum weight for landing as limited by aircraft strength and airworthiness requirements.

Maximum Design Takeoff Weight (MTOW). Maximum weight for takeoff as limited by aircraft strength and airworthiness requirements. (This is the maximum weight at start of the takeoff run.)

Operating Empty Weight (OEW). Weight of structure, powerplant, furnishing systems, unusable fuel and other unusable propulsion agents, and other items of equipment that are considered an integral part of a particular airplane configuration. Also included are certain standard items, personnel, equipment, and supplies necessary for full operations, excluding usable fuel and payload.

Maximum Design Zero Fuel Weight (MZFW). Maximum weight allowed before usable fuel and other specified usable agents must be loaded in defined sections of the aircraft as limited by strength and airworthiness requirements.

Maximum Pay load. Maximum design zero fuel weight minus operational empty weight.

Usable Fuel. Fuel available for aircraft propulsion.

V1: Go or No-Go Speed. The crew must rejected a Take-Off before reaching this speed in order to safely stop on remaining runway.

Vr: Rotation Speed. At this speed the crew begin to rotate the plane, smoothly nose-up to reach the max 8 deg of pitch attitude before the plane has left the runway, then the crew will carefully increase the pith up to 10/12 deg and they will maintein this attitude till the V2 +10 kt

V2: Take-Off safety Speed. Overstepping V2, with increasing speed gear up.

N1: Engine Fan Speed. N1 is used as a percentage of the max power. Normally the turbofans of the engines can overrun the 100% of N1 for short periods of time.

Measures

	ft	m		ft	m		ft	m
Length	231'10"	70.7	Wing Span	211'5"	64.4	Height	63'8"	19.4

Weights

			CF6-80C2B5F Engines	PW4062 Engines	RB211-524H Engines
Max Design Taxi Weight	MTW	Lb	877,000	877,000	877,000
		Kg	397,800	397,800	397,800
Max Design Take-off Weight	MTOW	Lb	875,000	875,000	875,000
		Kg	396,893	396,893	396,893
Max Design Landing Weight	MLW	Lb	630,000	630,000	630,000
		Kg	285,763	285,763	285,763
Max Design Zero Fuel Weight	MZFW	Lb	542,500	542,500	545,000
		Kg	246,073	246,073	247,207
Spec Operating Empty Weight	OEW	Lb	394,088	394,660	396,284
		Kg	178,757	178,984	179,753
Max Structural Payload		Lb	148,412	147,840	148,716
		Kg	67,316	67,089	67,545
Usable Fuel Capacity		Lb	382,336	382,336	382,336
		Kg	173,395	173,395	173,395

Engines

Maximum Allowable N1 117.5%

The 747-400 is equipped with four advanced high bypass ratio engines. The following table shows the available engines. Additional models may be available through customer options.

Manufacturer	Model Number	Rated Takeoff Thrust (Lb)
4 x 257kN GENERAL ELECTRIC	CF6-80C2B1F	57,900
4 x 257kN GENERAL ELECTRIC	CF6-80C2B5F	62,100
4 x 290kN GE-PW Engine Alliance	GP 7000*	65,250
4 x 252kN PRATT & WHITNEY	PW4056	56,750
4 x 266kN PRATT & WHITNEY	PW4060	60,000
4 x 275kN PRATT & WHITNEY	PW4062	63,300
4 x 258kN ROLLS-ROYCE	RB211-524G	58,000
4 x 258kN ROLLS-ROYCE	RB211-524H	69,500
4 x 290kN ROLLS-ROYCE	Trent 600*	65,250

* not yet available

Operating Performance 747-400 (KIAS/Mach)

V_A - Design Maneuvering Speed (KIAS/Mach)

	Sea Level	10,000ft	20,000ft	29,000/40,000ft
	300	315	330	336/0.86

V_{LO}	270/0.82	Max Speed @ Gear Retraction
V_{LO}	270/0.82	Max Speed @ Gear Extension
V_{LE}	320/0.82	Maximum Airspeed with Gear Extended

Maximum Tire Limit Speed 204 Kt

V_{NO}/M_{NO}	0.85	Normal Operating Speed
V_{ne}/M_{ne}	365/0.89	Never Exceed Speed

V_{MO}/M_{MO} - Max. Operating Limit Speed (KIAS/Mach) - Shall not be exceeded during any phase of flight

	20,000 ft & Lower	25,000ft	30,000ft	35,000	40,000ft
	365	365/0.88	340/0.90	309/0.90	269/0.90

Vat 150 –156 KIAS Landing @ Runway Threshold Speed @ MLW full flap/Gear down

Maximum Turbulent Air Penetration Speed (KIAS/Mach)

250	15,000 ft and Lower alt.	290 / 0.78	15,000 ft and Higher alt.
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Taxi Speed

	Straight Taxiway	45 deg Turn	90 deg Turn
	25 Kt	15 Kt	10 Kt

Max Slats/Flaps Extension Speed V_{fe} in KIAS

Config	Slats/Flaps		
1	Slats (inboard + Midspan only)	280	Intermediate Approach
5	Full Slats + Flaps @ 5 deg	260	Intermediate Approach
10	Full Slats + Flaps @ 10 deg	240	Take-Off & Approach
20	Full Slats + Flaps @ 20 deg	230	Take-Off & Approach
25	Full Slats + Flaps @ 25 deg	205	Landing
30	Full Slats + Flaps @ 30 deg	180	Landing

Flaps/Slats Selection

Take-Off	10, 20
Approach	10, 20, 25
Landing	25, 30

Take-off speed @ MTOW (875,000 Lbs) Flaps at 10 - 20 (MTOW = Max Take-Off Weight)

	Flaps 10	Flaps 20		
V1	159 (155*)	154 (148*)	KIAS	(V1 is the go or no-go decision speed)
VR	177	170	KIAS	(VR is the rotation speed ie lift-off speed)
V2	188	181	KIAS	(V2 is the safe climb-out speed)

* with wet/cluttered conditions

Take-off speed @ DXPW (635,000 Lbs) Flaps at 10 - 20 (DXPW = Default X-Plane Weight)

	Flaps 10	Flaps 20		
V1	129 (127*)	127 (129*)	KIAS	(V1 is the go or no-go decision speed)
VR	143	138	KIAS	(VR is the rotation speed ie lift-off speed)
V2	161	155	KIAS	(V2 is the safe climb-out speed)

* with wet/cluttered conditions

Take-off speeds in KIAS

Weight in Lbs.x 1,000	Flaps 10				Flaps 20			
	V1	V1*	Vr	V2	V1	V1*	Vr	V2
440 ÷ 540	127	127	127	149	127	127	127	147
550 ÷ 560	127	127	129	150	127	127	127	146
570 ÷ 580	127	127	132	153	127	127	128	146
590 ÷ 600	127	127	136	155	127	127	130	149
610 ÷ 620	127	127	139	158	127	127	134	152
630 ÷ 650 (DXPW)	129	127	143	161	127	129	138	155
660 ÷ 670	133	127	147	164	128	127	141	158
680 ÷ 690	136	128	150	166	131	127	145	160
700 ÷ 710	139	128	154	169	134	127	148	163
720 ÷ 730	142	132	157	172	137	127	151	166
740 ÷ 760	145	135	160	175	140	130	155	169
770 ÷ 780	148	139	164	177	143	134	158	171
790 ÷ 800	151	143	167	180	146	137	161	174
810 ÷ 820	154	146	170	183	149	140	164	176
830 ÷ 840	156	150	173	185	151	144	167	178
850 ÷ 870	158	152	175	187	153	146	169	180
875 (MTOW)	159	155	177	188	154	148	170	181

V1 is the go or no-go decision speed

VR is the rotation speed ie lift-off speed

V2 is the safe climb-out speed

MTOW Max Take-Off Weight

DXPW = Default X-Plane Weight

* with wet/cluttered conditions

Minimum Maneuvering and Landing Reference Speeds in KIAS

Weight x 1,000		Flaps						
Lbs	Kgs	0	1	5	10	20	25	30
400	180	202	182	162	142	132	125	121
410	185	204	184	164	144	133	127	123
420	190	205	185	165	145	135	129	124
430	195	206	186	166	146	136	130	125
440	200	208	188	168	148	138	132	127
450	205	209	189	169	149	139	133	128
460	210	211	190	170	152	142	135	130
470	215	212	192	172	152	142	137	131
480	220	213	193	173	153	143	138	132
490	225	215	195	175	155	146	140	134
500	227	215	196	176	156	146	141	135
510	230	218	198	178	158	148	143	137
520	235	220	200	179	160	150	145	139
530	240	221	201	181	161	151	146	140
540	245	222	202	182	162	152	147	141
550	250	226	204	183	164	154	149	143
560	255	225	205	185	165	155	150	144
570	260	227	207	186	167	157	152	146
580	265	228	209	188	168	158	153	147
590	268	229	210	189	170	159	154	148
600	270	230	211	190	171	161	156	150
610	275	232	212	192	172	162	157	151
620	280	233	213	193	173	163	158	152
630	285	234	213	194	174	164	160	153
640	290	236	216	196	176	166	161	155
650	295	237	217	197	177	167	162	156
660	300	238	218	198	178	168	164	157
670	305	239	219	199	179	169	165	158
680	310	240	220	200	180	170	166	159
690	313	242	222	202	182	172	168	161
700	315	243	223	202	183	173	169	162
710	320	245	225	205	185	175	171	164
720	325	246	226	206	186	176	172	165
730	330	246	226	206	186	177	173	165

Red speeds are above the maximum structural landing weight MLW.

----- DO NOT Exceed 250kts @ or Below 10,000ft Altitude -----

Stall Speed

Weight		Flaps						
Lbs	Kgs	0	1	5	10	20	25	30
X 1,000		Gear UP	Gear DN	Gear DN				
480	213	152	136	129	124	121	116	112
520	231	159	140	132	130	126	120	116
560	250	166	147	137	134	129	125	120
600	268	172	152	143	139	134	129	123
640	286	178	157	147	143	138	134	128
680	304	184	162	152	149	143	138	132
720	322	189	167	157	153	148	142	136
760	340	196	172	163	159	152	146	140
800	358	202	177	167	163	156	152	146
840	376	208	183	176	167	163	156	150
880	394	214	189	180	172	166	160	152

Take-Off Thrust Settings (N1)

Temp	Sea	2,000ft	4,000ft	6,000ft	8,000ft	10,000ft	12,000ft	13,000ft +
F / C	Level	500m	1,000m	1,500m	2,000m	2,500m	3,000m	4,000m +
120 / 49	100.3	102.6	104.6	107.2	109.1	109.9	109.9	109.9
110 / 43	101.1	103.3	105.4	107.9	109.8	109.9	109.9	109.9
100 / 38	101.8	104.0	106.0	108.4	109.9	109.9	109.9	109.9
90 / 32	102.7	104.8	106.8	109.1	109.9	109.9	109.9	109.9
80 / 27	106.3	107.2	108.4	108.9	109.9	109.9	109.9	109.9
70 / 21	105.2	106.3	107.3	108.0	109.8	109.9	109.9	109.9
60 / 16	104.3	105.4	106.6	107.3	108.9	109.6	109.9	109.9
50 / 10	103.0	104.3	105.4	106.4	108.2	108.9	109.8	109.9
40 / 4	102.1	103.4	104.6	105.7	107.3	107.8	108.7	109.9
30 / -1	101.4	102.7	103.9	104.8	106.4	106.9	107.8	109.2
20 / -7	100.3	101.6	102.8	103.9	105.3	105.8	106.9	108.1
10 / -12	99.4	100.7	101.9	103.0	104.4	104.9	105.6	107.2
0 / -18	98.4	99.6	100.8	101.9	103.3	103.9	104.7	106.2
-20 / -29	96.4	97.6	98.9	99.9	101.4	101.9	103.7	104.2

The Maximum Allowable N1 is 117.5% for shorts periods

To determinate the correct N1 setting in various temperature/altitude configurations follow these steps:

read the Outside Air temperature, read the pressure altitude of the departure airport then choose the correct N1 value from the above table.

Climb Speeds

Typical Climbing speeds	250 KIAS	to 10,000 feet
	300 KIAS	to FL310 (31,000 ft)
	0.80 Mach	above FL310 (31,000 ft)

Cruise Speeds are in KTAS (Knots True Air Speed)

Max Cruising speed	507 KTAS	
Cruise Speed	490 KTAS	@ 28,000 – 35,000ft
Typical Cruise Speed is	0.80 - 0.85 Mach	@ FL280 - FL350 (30,000-35,000ft)
Long Range Cruise is	496 KTAS	@ FL350 (35,000 ft)

Descent Speeds

Typical descending speeds	0.80 Mach	to FL340 (34.000 ft)
	300 KIAS	between FL340 (34,000 ft) and 10,000 ft
	250 KIAS	below 10,000 ft

When flying long routes (over 5hrs) with MTOW, climb to FL300 & hold Alt with cruise speed 0.80 - 0.81 Mach , then fly that level for 30-45 min. then climb to FL310 - 320 @500 fpm and so on until you reach FL350 @ 0.80 - 0.85 Mach.

Try not exceed 91% N1 during cruise in order to have available thrust for emergencies & be more efficient with fuel burn. The reason we mentioned the above procedure with X-Plane is to avoid too much nose pitch up attitude which put the aircraft wing @ higher angle of attack causing speed bleed leading to a clean stall if you are not careful.

The time taken between cruise climb is important because the aircraft will burn fuel (losing weight), your speed will gradually increase @ the same N1 setting , your aircraft pitch up will decrease helping you for the next cruise climb. Rate of climb at these alts should be between 300-500 fpm in order not to lose speed rapidly. The more you climb to FL350 the more the air density is less the better the engine fuel consumption (more range) & the less is thrust. You should carry fuel enough for the flight + 40 minutes for diversions & emergencies i.e. if your trip is 5hrs long, you load fuel for the required 5hrs flight plus fuel for an extra 40 min. You should know your aircraft average fuel consumption for the type of engines fitted with in order to determine the fuel weight required for the flight. Remember that weight is drag, drag is more fuel burn which costs money (for virtual pilots flying for virtual airlines :), so do not carry fuel more than you need. You have a destination to go to & MLW limit. You do not want to arrive to your destination with total weight above MLW!.

In order to determine the fuel weight required for the flight, you need to know the trip length. For that, you can use PATHY 1.5, an interactive flight planner for X-Plane by Roland Voegtli downloadable at <http://x-plane.org/registry/Utilities/Utility/> .

Following the table below, choose the fuel quantity to load and add extra fuel for 40 min (see at the bottom of the table).

Fuel Load

Trip Length Nm	FL410 @ 479Kt		FL390 @ 479Kt		FL370 @ 479Kt		FL350 @ 481Kt		FL330 @ 486Kt		FL310 @ 488Kt	
	Time	Lbx1000										
8,000	16:45	350	16:40	357	16:40	356	16:35	355	16:30	362	16:25	381
7,600	15:55	338	15:55	339	15:50	338	15:45	337	15:40	344	15:35	353
7,200	15:00	316	15:00	317	14:45	316	14:40	315	14:40	321	14:30	331
6,800	14:10	298	14:10	299	14:05	298	14:00	297	14:00	303	13:55	313
6,400	13:20	275	13:20	276	13:20	275	13:15	275	13:10	280	13:05	290
6,000	12:30	258	12:30	259	12:30	258	12:25	257	12:20	261	12:15	270
5,600	11:45	238	11:40	238	11:40	237	11:35	239	11:30	244	11:25	254
5,200	10:50	222	10:50	221	10:45	222	10:40	224	10:35	230	10:30	240
4,800	10:00	198	10:00	197	9:55	198	9:50	200	9:45	206	9:40	215
4,400	9:10	186	9:10	186	9:10	186	9:05	188	9:05	200	8:55	210
4,000	8:20	169	8:20	169	8:20	169	8:15	172	8:15	176	8:10	184
3,600	7:30	152	7:30	153	7:30	152	7:25	155	7:25	165	7:20	176
3,200	6:45	136	6:45	137	6:40	136	6:40	140	6:40	160	6:35	172
2,800	5:50	121	5:50	121	5:45	121	5:45	124	5:40	128	5:40	134
2,400	5:00	103	5:00	103	5:00	103	4:55	105	4:55	108	4:50	113
2,000	4:15	88	4:15	88	4:10	88	4:10	90	4:10	93	4:05	98
1,400	3:20	73	3:20	73	3:20	74	3:20	75	3:20	77	3:15	80
1,000	2:30	62	2:30	62	2:30	63	2:30	65	2:25	66	2:20	69
800	1:40	46	1:41	47	1:40	48	1:40	49	1:35	50	1:35	51
400	1:05	34	1:05	34	1:05	35	1:05	36	1:05	36	1:00	37
+40 min	+20,000 lb											

Optimum and Maximum Cruise Altitudes

Altitude	Optimum Weight		Maximum Weight	
	Lbs	Kg	Lbs	Kg
FL420	470,000	213,000	520,000	238,000
FL410	500,000	227,500	550,000	250,000
FL400	520,000	238,000	570,000	247,500
FL390	550,000	250,000	600,000	272,500
FL380	570,000	247,500	630,000	285,000
FL370	600,000	272,500	670,000	305,000
FL360	630,000	285,000	700,000	315,000
FL350	670,000	305,000	740,000	335,000
FL340	700,000	315,000	770,000	350,000
FL330	740,000	335,000	810,000	367,500
FL320	770,000	350,000	840,000	385,000
FL310	810,000	367,500	870,000	395,000
FL300	840,000	385,000	-	-

FAR Field Lengths

Take-off	10,561 ft @ MTOW
Landing	7,870 ft @ MLW

Take-off Check List

Allowable Take-off Weight (MTOW or lower)	Checked
Flaps	Set
Trim	Set
Autopilot Controls	Off

Final Landing Check List

Gear	Down
Flaps/Slats	Set 25 or 30
Speed Brakes	Armed
ILS freq	Tuned

During Descent Check

Check Allowable Landing Weight (MLW 630,000 lb. or lower)
Review your ILS approach & Runway heading

ROC Rate Of Climb

Below 10,000ft max. 3,800 fpm @ 250kts (fpm is Feet per minute)

Climb Speed above 10,000ft to Cruise Flight Level FL

2200 fpm	from	10,000 - 20,000 ft	@ 280 – 340 kts
2000 - 1500 fpm	from	20,000 - 26,000 ft	
1500 - 400 fpm	from	26,000 - 35,000 ft	depending on weight.

ROD Rate Of Descent

From Cruise FL to 10,000ft hold 0.79 Mach until 290 kts, reduce thrust for 2500 fpm
Below 10,000ft rate of descent varies with ATC requirements, but is between 800 - 3000fpm
In normal conditions 250kts idle descent , then slow & configure speed so as to not add power until on Glide Slope. Use speedbrakes to slow down.

----- DO NOT Exceed 250kts @ or Below 10,000ft Altitude -----

Glide Slope descend is between 1500 - 500fpm depending on your situation
At Runway Threshold descend between 400 - 200fpm for a smooth touchdown landing.
B747-400 pilot eye view is high above ground so be aware of landings, this is not a B737!.

Happy X-Flight

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