# x86 Assembly Tutorial

**From 8086 to Intel Core Processors**

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# Contents

# 1 Introduction

## 1.1 Overview

The x86 architecture is a wide spread microprocessor architecture used today. From time to time it could be helpful to understand the architecture more in depth or even develop some parts of a program in assembly language because you either want to tune the performance or to reduce the space needed.

In this book I will go through the assembly language instructions found in modern x86 processors. I will start with the 8086 assembly language in chapter 2 and go on to the 8087 assembly language extensions in chapter 3, which is the first x87 floating point unit (FPU).

Further on I will visit the other CPUs in historical order. We go on with the 80286 in chapter 6, the 80386 in chapter 8 and the 80486 in chapter 10.

After that I will not go on with different processors but with features. This starts with the chapter Processor with CPUID which is the first feature I'll discuss. This is the base for all other features because with the `CPUID` you can determine all other features. This is because not every processor implements all features.

I start with the 8086 and go on through all other successing processors because some of the idiosyncrasies of the modern processors can be easier understand if you have the history in mind.

I will look at the processors from the softwares view. If there are differences in the hardware I do not concern as long as it does not influence the software run on the processor.

## 1.2 Environment

# 2 8086

## 2.1 Introduction

- released 1978 (Intel)
- Intel 8086
- Intel 8088
- AMD 8086
- AMD 8088

## 2.2 Special Commands

| | |
|---|---|
| TBD | HLT |
| TBD | LOCK |
| TBD | NOP |
| TBD | WAIT |

## 2.3 Moving Data Around

| | |
|---|---|
| TBD | CBW |
| TBD | CWD |
| TBD | LAHF |
| TBD | MOV |
| TBD | SAHF |
| TBD | XCHG |

## 2.4 Doing Arithmetic

| | |
|---|---|
| TBD | AAA |
| TBD | AAD |
| TBD | AAM |
| TBD | AAS |
| TBD | ADC |
| TBD | ADD |
| TBD | DAA |

| | |
|---|---|
| DAS | TBD |
| DEC | TBD |
| DIV | TBD |
| IDIV | TBD |
| IMUL | TBD |
| INC | TBD |
| MUL | TBD |
| NEG | TBD |
| SBB | TBD |
| SUB | TBD |
| XCHG | TBD |

## 2.5 Doing Boolean Arithmetic

| | |
|---|---|
| AND | TBD |
| NOT | TBD |
| OR | TBD |
| XOR | TBD |

## 2.6 Shifting and Rotating

| | |
|---|---|
| RCL | TBD |
| RCR | TBD |
| ROL | TBD |
| ROR | TBD |
| SAL | TBD |
| SAR | TBD |
| SHL | TBD |
| SHR | TBD |

## 2.7 Accessing Memory

| | |
|---|---|
| LDS | TBD |
| LEA | TBD |
| LES | TBD |
| LODS | TBD |
| MOV | TBD |
| MOVS | TBD |
| SCAS | TBD |
| STOS | TBD |
| XCHG | TBD |
| XLAT | TBD |

## 2.8 Conditions and Control Flow

| | |
|---|---|
| TBD | CLC |
| TBD | CLD |
| TBD | CMC |
| TBD | CMP |
| TBD | CMPS |
| TBD | Jcc |
| TBD | JMP |
| TBD | LOOP/LOOPcc |
| TBD | REPcc |
| TBD | STC |
| TBD | STD |
| TBD | TEST |

## 2.9 Using Subroutines

| | |
|---|---|
| TBD | CALL |
| TBD | POP |
| TBD | POPF |
| TBD | PUSH |
| TBD | PUSHF |
| TBD | RET |

## 2.10 Interrupting Work and Using System Subroutines

| | |
|---|---|
| TBD | CLI |
| TBD | INT |
| TBD | INTO |
| TBD | IRET |
| TBD | STI |

## 2.11 Communicating with Periphery

| | |
|---|---|
| TBD | IN |
| TBD | OUT |

# 3 8087

- released 1980 (Intel)
- Intel 8087

| | |
|---|---|
| TBD | F2XM1 |
| TBD | FABS |
| TBD | FADD |
| TBD | FADDP |
| TBD | FBLD |
| TBD | FBSTP |
| TBD | FCHS |
| TBD | FCLEX |
| TBD | FCOM |
| TBD | FCOMP |
| TBD | FCOMPP |
| TBD | FDECSTP |
| TBD | FDISI |
| TBD | FDIV |
| TBD | FDIVP |
| TBD | FDIVR |
| TBD | FDIVRP |
| TBD | FENI |
| TBD | FFREE |
| TBD | FIADD |
| TBD | FICOM |
| TBD | FICOMP |
| TBD | FIDIV |
| TBD | FIDIVR |
| TBD | FILD |
| TBD | FIMUL |
| TBD | FINCSTP |
| TBD | FINIT |
| TBD | FIST |
| TBD | FISTP |
| TBD | FISUB |
| TBD | FISUBR |
| TBD | FLD |

| | |
|---|---|
| FLD1 | TBD |
| FLDCW | TBD |
| FLDENV | TBD |
| FLDL2E | TBD |
| FLDL2T | TBD |
| FLDLG2 | TBD |
| FLDLN2 | TBD |
| FLDPI | TBD |
| FLDZ | TBD |
| FMUL | TBD |
| FMULP | TBD |
| FNCLEX | TBD |
| FNDISI | TBD |
| FNENI | TBD |
| FNINIT | TBD |
| FNOP | TBD |
| FNSAVE | TBD |
| FNSTCW | TBD |
| FNSTENV | TBD |
| FNSTSW | TBD |
| FPATAN | TBD |
| FPREM | TBD |
| FPTAN | TBD |
| FRNDINT | TBD |
| FRSTOR | TBD |
| FSAVE | TBD |
| FSCALE | TBD |
| FST | TBD |
| FSTCW | TBD |
| FSTENV | TBD |
| FSTP | TBD |
| FSTSW | TBD |
| FSUB | TBD |
| FSUBP | TBD |
| FSUBR | TBD |
| FSUBP | TBD |
| FTST | TBD |
| FWAIT | TBD |
| FXAM | TBD |
| FXCH | TBD |
| FXTRACT | TBD |
| FYL2X | TBD |
| FYL2XP1 | TBD |

# 4 80186

- released 1982 (Intel)
- Intel 80186

| | |
|---|---|
| TBD | BOUND |
| TBD | ENTER |
| TBD | INS |
| TBD | LEAVE |
| TBD | OUTS |
| TBD | POPA |
| TBD | PUSHA |
| TBD (immediate) | PUSH |
| TBD (immediate) | IMUL |
| TBD (immediate) | SHL |
| TBD (immediate) | SHR |
| TBD (immediate) | SAL |
| TBD (immediate) | SAR |
| TBD (immediate) | ROL |
| TBD (immediate) | ROR |
| TBD (immediate) | RCL |
| TBD (immediate) | RCR |

# 5 80187

- released ??? (Intel)
- Intel 80187 (8087 interface/80387 core)

# 6 80286

- released 1982 (Intel)
- Intel 80286
- i286 (Intel)
- Am286 (AMD)

| | |
|---|---|
| TBD | ARPL |
| TBD | CLTS |
| TBD | LAR |
| TBD | LGDT |
| TBD | LIDT |
| TBD | LLDT |
| TBD | LMSW |
| TBD | LSL |
| TBD | LTR |
| TBD | SGDT |
| TBD | SIDT |
| TBD | SLDT |
| TBD | SMSW |
| TBD | STR |
| TBD | VERR |
| TBD | VERW |

# 7 80287

- released ??? (Intel)
- Intel 80287
- i287 (Intel)

TBD FSETPM

# 8 80386

- released 1985 (Intel)
- Intel 80386
- i386 (Intel)
- Am386 (AMD)

| | |
|---|---|
| TBD (extend) | ADC |
| TBD (extend) | ADD |
| TBD (extend) | AND |
| TBD (extend) | BOUND |
| TBD | BSF |
| TBD | BSR |
| TBD | BT |
| TBD | BTC |
| TBD | BTR |
| TBD | BTS |
| TBD (extend) | CALL |
| TBD | CDQ |
| TBD (extend) | CMP |
| TBD (extend) | CMPS |
| TBD | CWDE |
| TBD (extend) | DEC |
| TBD (extend) | DIV |
| TBD (extend) | ENTER |
| TBD (extend) | IDIV |
| TBD (extend) | IMUL |
| TBD (extend) | IN |
| TBD (extend) | INC |
| TBD (extend) | INS |
| TBD (extend) | IRET |
| TBD (extend) | Jcc |
| TBD (extend) | JMP |
| TBD (extend) | LAR |
| TBD | LFS |
| TBD | LGS |
| TBD | LSS |

| | |
|---|---|
| LEA | TBD (extend) |
| LEAVE | TBD (extend) |
| LODS | TBD (extend) |
| LOOP/LOOPcc | TBD (extend) |
| LSL | TBD (extend) |
| MOV | TBD (extend) |
| MOVS | TBD (extend) |
| MOVSX | TBD |
| MOVZX | TBD |
| MUL | TBD (extend) |
| NEG | TBD (extend) |
| NOT | TBD (extend) |
| OR | TBD (extend) |
| OUT | TBD (extend) |
| OUTS | TBD (extend) |
| POP | TBD (extend) |
| POPA | TBD (extend) |
| POPF | TBD (extend) |
| PUSH | TBD (extend) |
| PUSHA | TBD (extend) |
| PUSHF | TBD (extend) |
| RCL | TBD (extend) |
| RCR | TBD (extend) |
| REPcc | TBD (extend) |
| ROL | TBD (extend) |
| ROR | TBD (extend) |
| SAL | TBD (extend) |
| SAR | TBD (extend) |
| SBB | TBD (extend) |
| SCAS | TBD (extend) |
| SETcc | TBD |
| SGDT | TBD (extend) |
| SHL | TBD (extend) |
| SHLD | TBD |
| SHR | TBD (extend) |
| SHRD | TBD |
| SIDT | TBD (extend) |
| SMSW | TBD (extend) |
| STOS | TBD (extend) |
| SUB | TBD (extend) |
| TEST | TBD (extend) |
| XCHG | TBD (extend) |
| XLAT | TBD (extend) |
| XOR | TBD (extend) |

# 9 80387

- released 1987 (Intel)
- Intel 80387
- i387 (Intel)

| | |
|---|---|
| TBD | FCOS |
| TBD (extend) | FNSAVE |
| TBD (extend) | FNSTENV |
| TBD (extend) | FNSTSW |
| TBD | FPREM1 |
| TBD (extend) | FRSTOR |
| TBD (extend) | FSAVE |
| TBD (extend) | FSTENV |
| TBD (extend) | FSTSW |
| TBD | FSIN |
| TBD | FSINCOS |
| TBD | FUCOM |
| TBD | FUCOMP |
| TBD | FUCOMPP |

# 10 80486

- released 1989 (Intel)
- i486 (Intel)
- Am486 (AMD)
- Am5x86 (AMD)

| | |
|---|---|
| TBD | BSWAP |
| TBD | CMPXCHG |
| TBD | INVD |
| TBD | INVLPG |
| TBD | WBINVD |
| TBD | XADD |

# 11 RSM

- released 1993 (Intel)

TBD

RSM

# 12 Processor with CPUID

- released 1993 (Intel)
- Intel Pentium (Intel)
- AMD K5 (AMD)

TBD CPUID

# 13 CX8

- released 1993 (Intel)

TBD CMPXCHG8B

# 14 MSR

- released 1993 (Intel)

| | |
|---|---|
| TBD | RDMSR |
| TBD | WRMSR |

# 15 TSC

- released 1993 (Intel)
- Invariant TSC

TBD RDTSC

# 16 PMC

- released 1997 (Intel)

TBD RDPMC

# 17 MMX

- released 1997 (Intel)

| | |
|---|---|
| TBD | EMMS |
| TBD | MOVD |
| TBD | MOVQ |
| TBD | PACKSSDW |
| TBD | PACKSSWB |
| TBD | PACKUSWB |
| TBD | PADDB |
| TBD | PADDW |
| TBD | PADDD |
| TBD | PADDQ |
| TBD | PADDSB |
| TBD | PADDSW |
| TBD | PADDUSB |
| TBD | PADDUSW |
| TBD | PAND |
| TBD | PANDN |
| TBD | PCMPEQB |
| TBD | PCMPEQW |
| TBD | PCMPEQD |
| TBD | PCMPGTB |
| TBD | PCMPGTW |
| TBD | PCMPGTD |
| TBD | PMADDWD |
| TBD | PMULHW |
| TBD | PMULLW |
| TBD | POR |
| TBD | PSLLW |
| TBD | PSLLD |
| TBD | PSLLQ |
| TBD | PDRAW |
| TBD | PDRAD |
| TBD | PDRAQ |
| TBD | PDRLW |
| TBD | PDRLD |
| TBD | PDRLQ |

| | |
|---|---|
| PSUBB | TBD |
| PSUBW | TBD |
| PSUBD | TBD |
| PSUBSB | TBD |
| PSUBSW | TBD |
| PSUBUSB | TBD |
| PSUBUSW | TBD |
| PUNPCKHBW | TBD |
| PUNPCKHDQ | TBD |
| PUNPCKHWD | TBD |
| PUNPCKLBW | TBD |
| PUNPCKLDQ | TBD |
| PUNPCKLWD | TBD |
| PXOR | TBD |

# 18 Temp

This is a temporary chapter to help me organize this book.

- CLFSH
- CMPXCHG16B
- CMOV
- RDTSCP
- SEP
- SYSCALL/SYSRET in 64-bit Mode
- 3DNow (AMD)
- MMX ext (AMD)
- 3DNow ext (AMD)
- PREFETCHW (3DNow AMD)
- SSE
- SSE2
- SSE3
- SSSE3
- SSE4A (AMD)
- SSE4.2
- Intel 64 Architecture/Long Mode (AMD)
- MISCSELECT (SGX) (Intel)
- SGX1 (Intel)
- SGX2 (Intel)
- ENCLV (SGX) (Intel)

- ENCLS (SGX) (Intel)
- SVM (AMD)
- AVX
- AVX2
- XOP (AMD)
- AESNI (AES (AMD))
- FMA
- FMA4 (AMD)
- F16C
- RDRAND
- LZCNT (ABM (AMD))
- BMI1
- BMI2
- POPCNT
- TBM (AMD)
- MOVBE
- MONITOR
- MONITORX (AMD)
- PCMULQDQ
- FXSR
- SKINIT (AMD)
- LAHF/SAHF in 64-bit Mode
- FSGSBASE
- SHA
- CLFLUSHOPT (CLFLOPT (AMD))
- SMAP
- ADX

- RDSEED
- SME (AMD)
- SEV (AMD)
- PageFlushMgr (AMD)
- ES (AMD)
- CLZERO (AMD)
- Instruction Retired Counter (AMD)
- Error Pointer (AMD)
- XSAVEOPT
- XSAVEC
- XGETBV
- XSAVES
- XSAVE
- OSXSAVE
- HTT
- PSE-36
- PAT
- MCA
- PGE
- MTRR
- APIC
- MCE
- PAE
- PSE
- DE
- VME
- SMEP

- DTSE64 (Intel)
- MONITOR (Intel)
- DS-CPL (Intel)
- VMX (Intel)
- SMX (Intel)
- EIST (Intel)
- TM2 (Intel)
- CNXT-ID (Intel)
- SDBG (Intel)
- xTPR Update Control (Intel)
- PDCM (Intel)
- PCID (Intel)
- DCA (Intel)
- x2APIC (Intel)
- TSC-Deadline (Intel)
- PSN (Intel)
- DS (Intel)
- ACPI (Intel)
- SS (Intel)
- TM (Intel)
- PBE (Intel)
- Execute Disable Flag (Intel)
- IA32_TSC_ADJUST (Intel)
- HLE (Intel)
- INVPCID (Intel)
- RTM (Intel)
- RDT-M (Intel)

- MPX (Intel)
- RDT-A (Intel)
- AVX512F (Intel)
- AVX512DQ (Intel)
- AVX512_IFMA (Intel)
- CLWB (Intel)
- Intel Processor Trace (Intel)
- AVX512PF (Intel)
- AVX512ER (Intel)
- AVX512CD (Intel)
- AVX512BW (Intel)
- AVX512VL (Intel)

# A Glossary

**x86** a microprocessor architecture based on the 8086/8088 from Intel 5, 47

**x87** a mathematical coprocessor for the x86 5, 53–55

# B Acronyms

**BCD** binary coded decimal 52

**FPU** floating point unit 5, 53–55

**TLB** translation lookaside buffer 56

# C x86-Instructions

`AAA` ASCII adjust AL after addition, introduced with 8086 7

`AAD` ASCII adjust AX before division, introduced with 8086 7

`AAM` ASCII adjust AX after multiplication, introduced with 8086 7

`AAS` ASCII adjust AL after subtraction, introduced with 8086 7

`ADC` Add with carry, introduced with 8086, extended with 80386 7, 21

`ADD` Add, introduced with 8086, extended with 80386 7, 21

`AND` Logical AND, introduced with 8086, extended with 80386 8, 21

`ARPL` Adjust RPL field of selector, introduced with 80286 17

`BOUND` Check array index against bounds, introduced with 80186, extended with 80386 13, 21

`BSF` Bit scan forward, introduced with 80386 21

`BSR` Bit scan reverse, introduced with 80386 21

`BSWAP` Byte swap, introduced with 80486 25

`BTC` Bit test and complement, introduced with 80386 21

`BTR` Bit test and reset, introduced with 80386 21

`BTS` Bit test and set, introduced with 80386 21

`BT` Bit test, introduced with 80386 21

`CALL` Call procedure, introduced with 8086, extended with 80386 9, 21

`CBW` Convert byte to word, introduced with 8086 7

`CDQ` Convert double-word to quad-word, introduced with 80386 21

`CLC` Clear carry flag, introduced with 8086 9

`CLD` Clear direction flag, introduced with 8086 9

`CLI` Clear interrupt flag, introduced with 8086 9

`CLTS` Clear task-switched flag in CR0, introduced with 80286 17

`CMC` Complement carry flag, introduced with 8086 9

`CMPS` Compare string operands, introduced with 8086, extended with 80386 9, 21

`CMPXCHG8B` Compare and exchange bytes, introduced with CX8 31

`CMPXCHG` Compare and exchange, introduced with 80486 25

`CMP` Compare two operands, introduced with 8086, extended with 80386 9, 21

`CPUID` CPU identification, introduced with 80486 5, 29

`CWDE` Convert word to double-word, introduced with 80386 21

`CWD` Convert word to doubleword, introduced with 8086 7

`DAA` Decimal adjust AL after addition, introduced with 8086 7

`DAS` Decimal adjust AL after subtraction, introduced with 8086 8

`DEC` Decrement by 1, introduced with 8086, extended with 80386 8, 21

`DIV` Unsigned divide, introduced with 8086, extended with 80386 8, 21

`EMMS` Empty MMX technology state, introduced with MMX 39

`ENTER` Make stack frame for procedure parameters, introduced with 80186, extended with 80386 13, 21

`F2XM1` Computer $2^x - 1$, introduced with 8087 11

`FABS` Absolute value, introduced with 8087 11

`FADDP` Add and pop, introduced with 8087 11

`FADD` Add, introduced with 8087 11

`FBLD` Load binary coded decimal (BCD), introduced with 8087 11

`FBSTP` Store BCD integer and pop, introduced with 8087 11

`FCHS` Change sign, introduced with 8087 11

`FCLEX` Clear exceptions, introduced with 8087 11

`FCOMPP` Compare floating point values and pop twice, introduced with 8087 11

`FCOMP` Compare floating point values and pop, introduced with 8087 11

`FCOM` Compare floating point values, introduced with 8087 11

`FCOS` Cosine, introduced with 80387 23

`FDECSTP` Decrement stack-top pointer, introduced with 8087 11

`FDISI` Disable interrupts, introduced with 8087, `FNOP` on other FPUs 11

`FDIVP` Divide and pop, introduced with 8087 11

`FDIVRP` Reverse divide and pop, introduced with 8087 11

`FDIVR` Reverse divide, introduced with 8087 11

`FDIV` Divide, introduced with 8087 11

`FENI` Enable interrupts, introduced with 8087, `FNOP` on other FPUs 11

`FFREE` Free floating-pont register, introduced with 8087 11

`FIADD` Add integer, introduced with 8087 11

`FICOMP` Compare integer and pop, introduced with 8087 11

`FICOM` Compare integer, introduced with 8087 11

`FIDIVR` Reverse divide integer, introduced with 8087 11

`FIDIV` Divide integer, introduced with 8087 11

`FILD` Load integer, introduced with 8087 11

`FIMUL` Multiply integer, introduced with 8087 11

`FINCSTP` Increment stack-top pointer, introduced with 8087 11

`FINIT` Initialize floating point unit, introduced with 8087 11

`FISTP` Store integer and pop, introduced with 8087 11

`FIST` Store integer, introduced with 8087 11

`FISUBR` Reverse subtract integer, introduced with 8087 11

`FISUB` Subtract integer, introduced with 8087 11

`FLD1` Load constant 1.0, introduced with 8087 12

`FLDCW` Load x87 FPU control word, introduced with 8087 12

`FLDENV` Load x87 FPU environment, introduced with 8087 12

`FLDL2E` Load constant $log_2(e)$, introduced with 8087 12

`FLDL2T` Load constant $log_2(10)$, introduced with 8087 12

`FLDLG2` Load constant $log_10(2)$, introduced with 8087 12

`FLDLN2` Load constant $ln(2)$, introduced with 8087 12

`FLDPI` Load constant $\pi$, introduced with 8087 12

`FLDZ` Load constant 0.0, introduced with 8087 12

`FLD` Load floating point value, introduced with 8087 11

`FMULP` Multiply and pop, introduced with 8087 12

`FMUL` Multiply, introduced with 8087 12

`FNCLEX` Clear exceptions, no wait, introduced with 8087 12

`FNDISI` Disable interrupts, no wait, introduced with 8087, `FNOP` on other FPUs 12

`FNENI` Enable interrupts, no wait, introduced with 8087, `FNOP` on other FPUs 12

`FNINIT` Initialize floating point unit, no wait, introduced with 8087 12

`FNOP` No operation, introduced with 8087 12, 53, 54

`FNSAVE` Save x87 FPU state, no wait, introduced with 8087, extended with 80387 12, 23

`FNSTCW` Store x87 FPU control word, no wait, introduced with 8087 12

`FNSTENV` Store x87 FPU environment, no wait, introduced with 8087, extended with 80387 12, 23

`FNSTSW` Store x87 FPU status word, no wait, introduced with 8087, extended with 80387 12, 23

`FPATAN` Partial arctangent, introduced with 8087 12

`FPREM1` Partial remainder (IEEE), introduced with 80387 23

`FPREM` Partial remainder, introduced with 8087 12

`FPTAN` Partial tangent, introduced with 8087 12

`FRNDINT` Round to integer, introduced with 8087 12

`FRSTOR` Restore x87 FPU state, introduced with 8087, extended with 80387 12, 23

`FSAVE` Save x87 FPU state, introduced with 8087, extended with 80387 12, 23

`FSCALE` Scale, introduced with 8087 12

`FSETPM` Set protected mode, introduced with 80287, `FNOP` on other FPUs 19

`FSINCOS` Sine and cosine, introduced with 80387 23

`FSIN` Sine, introduced with 80387 23

`FSTCW` Store x87 FPU control word, introduced with 8087 12

`FSTENV` Store x87 FPU environment, introduced with 8087, extended with 80387 12, 23

`FSTP` Store floating point value and pop, introduced with 8087 12

`FSTSW` Store x87 FPU status word, introduced with 8087, extended with 80387 12, 23

`FST` Store floating point value, introduced with 8087 12

`FSUBP` Subtract and pop, introduced with 8087 12

`FSUBR` Reverse subtract, introduced with 8087 12

`FSUB` Subtract, introduced with 8087 12

`FTST` Test, introduced with 8087 12

`FUCOMPP` Unordered compare floating point values and pop twice, introduced with 80387 23

`FUCOMP` Unordered compare floating point values and pop, introduced with 80387 23

`FUCOM` Unordered compare floating point values, introduced with 80387 23

`FWAIT` Wait (opcode synonym for `WAIT`), introduced with 8087 12

`FXAM` Examine floating-point, introduced with 8087 12

`FXCH` Exchange register contents, introduced with 8087 12

`FXTRACT` Extract exponent and significand, introduced with 8087 12

`FYL2XP1` Compute $y * log_2(x + 1)$, introduced with 8087 12

`FYL2X` Compute $y * log_2 x$, introduced with 8087 12

`HLT` Halt, introduced with 8086 7

`IDIV` Signed divide, introduced with 8086, extended with 80386 8, 21

`IMUL` Signed multiply, introduced with 8086, extended with 80186, 80386 8, 13, 21

`INC` Increment by 1, introduced with 8086, extended with 80386 8, 21

`INS` Input from port to string, introduced with 80186, extended with 80386 13, 21

`INTO` Call to interrupt procedure if overflow, introduced with 8086 9

`INT` Call to interrupt procedure, introduced with 8086 9

`INVD` Invalidate internal caches, introduced with 80486 25

`INVLPG` Invalidate translation lookaside buffer (TLB) entries, introduced with 80486 25

`IN` Input from port, introduced with 8086, extended with 80386 9, 21

`IRET` Interrupt return, introduced with 8086, extended with 80386 9, 21

`JMP` Jump, introduced with 8086, extended with 80386 9, 21

`Jcc` Jump if condition is met, introduced with 8086, extended with 80386 9, 21

`LAHF` Load status flags into AH register, introduced with 8086 7

`LAR` Load access rights byte, introduced with 80286, extended with 80386 17, 21

`LDS` Load DS with far pointer, introduced with 8086 8

`LEAVE` High level procedure exit, introduced with 80186, extended with 80386 13, 22

`LEA` Load effective address, introduced with 8086, extended with 80386 8, 22

`LES` Load ES with far pointer, introduced with 8086 8

`LFS` Load FS with far pointer, introduced with 80386 21

`LGDT` Load global descriptor table register, introduced with 80286 17

`LGS` Load GS with far pointer, introduced with 80386 21

`LIDT` Load interrupt descriptor table register, introduced with 80286 17

`LLDT` Load local descriptor table register, introduced with 80286 17

`LMSW` Load machine status word, introduced with 80286 17

`LOCK` Assert LOCK# signal prefix, introduced with 8086 7

`LODS` Load string, introduced with 8086, extended with 80386 8, 22

`LOOP/LOOPcc` Loop according to (E/R)CX counter, introduced with 8086, extended with 80386 9, 22

`LSL` Load segment limit, introduced with 80286, extended with 80386 17, 22

`LSS` Load SS with far pointer, introduced with 80386 21

`LTR` Load task register, introduced with 80286 17

`MOVD` Move doubleword, introduced with MMX 39

`MOVQ` Move quadword, introduced with MMX 39

`MOVSX` Move with sign-extension, introduced with 80386 22

`MOVS` Move data from string to string, introduced with 8086, extended with 80386 8, 22

`MOVZX` Move with zero-extend, introduced with 80386 22

`MOV` Move, introduced with 8086, extended with 80386 7, 8, 22

`MUL` Unsigned multiply, introduced with 8086, extended with 80386 8, 22

`NEG` Two's complement negation, introduced with 8086, extended with 80386 8, 22

`NOP` No operation, introduced with 8086 7

`NOT` One's complement negation, logical NOT, introduced with 8086, extended with 80386 8, 22

`OR` Logical inclusive OR, introduced with 8086, extended with 80386 8, 22

`OUTS` Output string to port, introduced with 80186, extended with 80386 13, 22

`OUT` Output to port, introduced with 8086, extended with 80386 9, 22

`PACKSSDW` Pack doublewords with signed saturation, introduced with MMX 39

`PACKSSWB` Pack words with signed saturation, introduced with MMX 39

`PACKUSWB` Pack words with unsigned saturation, introduced with MMX 39

`PADDB` Add packed byte integers, introduced with MMX 39

`PADDD` Add packed doubleword integers, introduced with MMX 39

`PADDQ` Add packed quadword integers, introduced with MMX 39

`PADDSB` Add packed signed byte integers with signed saturation, introduced with MMX 39

`PADDSW` Add packed signed word integers with signed saturation, introduced with MMX 39

`PADDUSB` Add packed unsigned byte integers with unsigned saturation, introduced with MMX 39

`PADDUSW` Add packed unsigned word integers with unsigned saturation, introduced with MMX 39

`PADDW` Add packed word integers, introduced with MMX 39

`PANDN` Logical AND NOT, introduced with MMX 39

`PAND` Logical AND, introduced with MMX 39

`PCMPEQB` Compare packed bytes for equal, introduced with MMX 39

`PCMPEQD` Compare packed doublewords for equal, introduced with MMX 39

`PCMPEQW` Compare packed words for equal, introduced with MMX 39

`PCMPGTB` Compare packed signed bytes for greater than, introduced with MMX 39

`PCMPGTD` Compare packed signed doublewords for greater than, introduced with MMX 39

`PCMPGTW` Compare packed signed words for greater than, introduced with MMX 39

`PDRAD` Shift packed doublewords right arithmetic, introduced with MMX 39

`PDRAQ` Shift packed quadwords right arithmetic, introduced with MMX 39

`PDRAW` Shift packed words right arithmetic, introduced with MMX 39

`PDRLD` Shift packed doublewords right logical, introduced with MMX 39

`PDRLQ` Shift packed quadwords right logical, introduced with MMX 39

`PDRLW` Shift packed words right logical, introduced with MMX 39

`PMADDWD` Multiply and add packed integers, introduced with MMX 39

`PMULHW` Multiply packed signed integers and store high result, introduced with MMX 39

`PMULLW` Multiply packed signed integers and store low result, introduced with MMX 39

`POPA` Pop all general-purpose registers, introduced with 80186, extended with 80386 13, 22

`POPF` Pop stack into FLAGS register, introduced with 8086, extended with 80386 9, 22

`POP` Pop a value from the stack, introduced with 8086, extended with 80386 9, 22

`POR` Bitwise logical OR, introduced with MMX 39

`PSLLD` Shift packed doublewords left logical, introduced with MMX 39

`PSLLQ` Shift packed quadwords left logical, introduced with MMX 39

`PSLLW` Shift packed words left logical, introduced with MMX 39

`PSUBB` Subtract packed byte integers, introduced with MMX 40

`PSUBD` Subtract packed doubleword integers, introduced with MMX 40

`PSUBSB` Subtract packed signed bytes with signed saturation, introduced with MMX 40

`PSUBSW` Subtract packed signed words with signed saturation, introduced with MMX 40

`PSUBUSB` Subtract packed unsigned bytes with unsigned saturation, introduced with MMX 40

`PSUBUSW` Subtract packed unsigned words with unsigned saturation, introduced with MMX 40

`PSUBW` Subtract packed word integers, introduced with MMX 40

`PUNPCKHBW` Unpack high bytes, introduced with MMX 40

`PUNPCKHDQ` Unpack high doublewords, introduced with MMX 40

`PUNPCKHWD` Unpack high words, introduced with MMX 40

`PUNPCKLBW` Unpack low bytes, introduced with MMX 40

`PUNPCKLDQ` Unpack low doublewords, introduced with MMX 40

`PUNPCKLWD` Unpack low words, introduced with MMX 40

`PUSHA` Push all general-purpose registers, introduced with 80186, extended with 80386 13, 22

`PUSHF` Push FLAGS register onto the stack, introduced with 8086, extended with 80386 9, 22

`PUSH` Push data onto the stack, introduced with 8086, extended with 80186, 80386 9, 13, 22

`PXOR` Logical exclusive OR, introduced with MMX 40

`RCL` Rotate left through carry, introduced with 8086, extended with 80186, 80386 8, 13, 22

`RCR` Rotate right through carry, introduced with 8086, extended with 80186, 80386 8, 13, 22

`RDMSR` Read from model specific register, introduced with MSR 33

`RDPMC` Read performance-monitoring counters, introduced with PMC 37

`RDTSC` Read time-stamp counter, introduced with TSC 35

`REPcc` Repeat string operation prefix, introduced with 8086, extended with 80386 9, 22

`RET` Return from procedure, introduced with 8086 9

`ROL` Rotate left, introduced with 8086, extended with 80186, 80386 8, 13, 22

`ROR` Rotate right, introduced with 8086, extended with 80186, 80386 8, 13, 22

`RSM` Resume from system management mode, introduced with RSM 27

`SAHF` Store AH into flags, introduced with 8086 7

`SAL` Shift arithmetically left, introduced with 8086, extended with 80186, 80386 8, 13, 22

`SAR` Shift arithmetically right, introduced with 8086, extended with 80186, 80386 8, 13, 22

`SBB` Integer subtraction with borrow, introduced with 8086, extended with 80386 8, 22

`SCAS` Scan string, introduced with 8086, extended with 80386 8, 22

`SETcc` Set byte on condition, introduced with 80386 22

`SGDT` Store global descriptor table register, introduced with 80286, extended with 80386 17, 22

`SHLD` Double precision shift left, introduced with 80386 22

`SHL` Shift left, introduced with 8086, extended with 80186, 80386 8, 13, 22

`SHRD` Double precision shift right, introduced with 80386 22

`SHR` Shift right, introduced with 8086, extended with 80186, 80386 8, 13, 22

`SIDT` Store interrupt descriptor table register, introduced with 80286, extended with 80386 17, 22

`SLDT` Store local descriptor table register, introduced with 80286 17

`SMSW` Store machine status word, introduced with 80286, extended with 80386 17, 22

`STC` Set carry flag, introduced with 8086 9

`STD` Set direction flag, introduced with 8086 9

`STI` Set interrupt flag, introduced with 8086 9

`STOS` Store string, introduced with 8086, extended with 80386 8, 22

`STR` Store task register, introduced with 80286 17

`SUB` Subtract, introduced with 8086, extended with 80386 8, 22

`TEST` Logical compare, introduced with 8086, extended with 80386 9, 22

`VERR` Verify a segment for reading, introduced with 80286 17

`VERW` Verify a segment for writing, introduced with 80286 17

`WAIT` Wait, introduced with 8086 7, 55

`WBINVD` Write back and invalidate cache, introduced with 80486 25

`WRMSR` Write to model specific register, introduced with MSR 33

`XADD` Exchange and add, introduced with 80486 25

`XCHG` Exchange register/memory with register, introduced with 8086, extended with 80386 7, 8, 22

`XLAT` Table look-up translation, introduced with 8086, extended with 80386 8, 22

`XOR` Logical exclusive OR, introduced with 8086, extended with 80386 8, 22

# D Code Chunks

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# F Index

# G Instruction Index