

# Appendix A: Ethereum EVM Opcodes and Gas Consumption

This appendix is based on the consolidation work done by the people of <https://github.com/trailofbits/evm-opcodes> as a reference for Ethereum VM (EVM) opcodes and instruction information licensed under the [Apache License 2.0](#).

Table 1. EVM opcodes and gas cost

Opcode	Name	Description	Extra info	Gas
0x00	STOP	Halts execution	-	0
0x01	ADD	Addition operation	-	3
0x02	MUL	Multiplication operation	-	5
0x03	SUB	Subtraction operation	-	3
0x04	DIV	Integer division operation	-	5
0x05	SDIV	Signed integer division operation (truncated)	-	5
0x06	MOD	Modulo remainder operation	-	5
0x07	SMOD	Signed modulo remainder operation	-	5
0x08	ADDMOD	Modulo addition operation	-	8
0x09	MULMOD	Modulo multiplication operation	-	8
0x0a	EXP	Exponential operation	-	10***
0x0b	SIGNEXTEND	Extend length of two's complement signed integer	-	5
0x0c - 0x0f	Unused	Unused	-	
0x10	LT	Less-than comparison	-	3
0x11	GT	Greater-than comparison	-	3

Opcode	Name	Description	Extra info	Gas
0x12	SLT	Signed less-than comparison	-	3
0x13	SGT	Signed greater-than comparison	-	3
0x14	EQ	Equality comparison	-	3
0x15	ISZERO	Simple NOT operator	-	3
0x16	AND	Bitwise AND operation	-	3
0x17	OR	Bitwise OR operation	-	3
0x18	XOR	Bitwise XOR operation	-	3
0x19	NOT	Bitwise NOT operation	-	3
0x1a	BYTE	Retrieve single byte from word	-	3
0x1b - 0x1f	Unused	Unused	-	
0x20	SHA3	Compute Keccak-256 hash	-	30
0x21 - 0x2f	Unused	Unused	-	
0x30	ADDRESS	Get address of currently executing account	-	2
0x31	BALANCE	Get balance of the given account	-	400
0x32	ORIGIN	Get execution origination address	-	2
0x33	CALLER	Get caller address	-	2
0x34	CALLVALUE	Get deposited value by the instruction/transaction responsible for this execution	-	2
0x35	CALLDATALOAD	Get input data of current environment	-	3

Opcode	Name	Description	Extra info	Gas
0x36	CALLDATASIZE	Get size of input data in current environment	-	2
0x37	CALLDATACOPY	Copy input data in current environment to memory	-	3
0x38	CODESIZE	Get size of code running in current environment	-	2
0x39	CODECOPY	Copy code running in current environment to memory	-	3
0x3a	GASPRICE	Get price of gas in current environment	-	2
0x3b	EXTCODESIZE	Get size of an account's code	-	700
0x3c	EXTCODECOPY	Copy an account's code to memory	-	700
0x3d	RETURNDATASIZE	Pushes the size of the return data buffer onto the stack	<a href="#">EIP-211</a>	2
0x3e	RETURNDATACOPY	Copies data from the return data buffer to memory	<a href="#">EIP-211</a>	3
0x3f	Unused	-	-	
0x40	BLOCKHASH	Get the hash of one of the 256 most recent complete blocks	-	20
0x41	COINBASE	Get the block's beneficiary address	-	2
0x42	TIMESTAMP	Get the block's timestamp	-	2
0x43	NUMBER	Get the block's number	-	2

Opcode	Name	Description	Extra info	Gas
0x44	DIFFICULTY	Get the block's difficulty	-	2
0x45	GASLIMIT	Get the block's gas limit	-	2
0x46 - 0x4f	Unused	-	-	
0x50	POP	Remove word from stack	-	2
0x51	MLOAD	Load word from memory	-	3
0x52	MSTORE	Save word to memory	-	3*
0x53	MSTORE8	Save byte to memory	-	3
0x54	SLOAD	Load word from storage	-	200
0x55	SSTORE	Save word to storage	-	0*
0x56	JUMP	Alter the program counter	-	8
0x57	JUMPI	Conditionally alter the program counter	-	10
0x58	GETPC	Get the value of the program counter prior to the increment	-	2
0x59	MSIZE	Get the size of active memory in bytes	-	2
0x5a	GAS	Get the amount of available gas, including the corresponding reduction in the amount of available gas	-	2
0x5b	JUMPDEST	Mark a valid destination for jumps	-	1
0x5c - 0x5f	Unused	-	-	

Opcode	Name	Description	Extra info	Gas
0x60	PUSH1	Place 1-byte item on stack	-	3
0x61	PUSH2	Place 2-byte item on stack	-	3
0x62	PUSH3	Place 3-byte item on stack	-	3
0x63	PUSH4	Place 4-byte item on stack	-	3
0x64	PUSH5	Place 5-byte item on stack	-	3
0x65	PUSH6	Place 6-byte item on stack	-	3
0x66	PUSH7	Place 7-byte item on stack	-	3
0x67	PUSH8	Place 8-byte item on stack	-	3
0x68	PUSH9	Place 9-byte item on stack	-	3
0x69	PUSH10	Place 10-byte item on stack	-	3
0x6a	PUSH11	Place 11-byte item on stack	-	3
0x6b	PUSH12	Place 12-byte item on stack	-	3
0x6c	PUSH13	Place 13-byte item on stack	-	3
0x6d	PUSH14	Place 14-byte item on stack	-	3
0x6e	PUSH15	Place 15-byte item on stack	-	3
0x6f	PUSH16	Place 16-byte item on stack	-	3
0x70	PUSH17	Place 17-byte item on stack	-	3
0x71	PUSH18	Place 18-byte item on stack	-	3
0x72	PUSH19	Place 19-byte item on stack	-	3

Opcode	Name	Description	Extra info	Gas
0x73	PUSH20	Place 20-byte item on stack	-	3
0x74	PUSH21	Place 21-byte item on stack	-	3
0x75	PUSH22	Place 22-byte item on stack	-	3
0x76	PUSH23	Place 23-byte item on stack	-	3
0x77	PUSH24	Place 24-byte item on stack	-	3
0x78	PUSH25	Place 25-byte item on stack	-	3
0x79	PUSH26	Place 26-byte item on stack	-	3
0x7a	PUSH27	Place 27-byte item on stack	-	3
0x7b	PUSH28	Place 28-byte item on stack	-	3
0x7c	PUSH29	Place 29-byte item on stack	-	3
0x7d	PUSH30	Place 30-byte item on stack	-	3
0x7e	PUSH31	Place 31-byte item on stack	-	3
0x7f	PUSH32	Place 32-byte (full word) item on stack	-	3
0x80	DUP1	Duplicate 1st stack item	-	3
0x81	DUP2	Duplicate 2nd stack item	-	3
0x82	DUP3	Duplicate 3rd stack item	-	3
0x83	DUP4	Duplicate 4th stack item	-	3
0x84	DUP5	Duplicate 5th stack item	-	3
0x85	DUP6	Duplicate 6th stack item	-	3

Opcode	Name	Description	Extra info	Gas
0x86	DUP7	Duplicate 7th stack item	-	3
0x87	DUP8	Duplicate 8th stack item	-	3
0x88	DUP9	Duplicate 9th stack item	-	3
0x89	DUP10	Duplicate 10th stack item	-	3
0x8a	DUP11	Duplicate 11th stack item	-	3
0x8b	DUP12	Duplicate 12th stack item	-	3
0x8c	DUP13	Duplicate 13th stack item	-	3
0x8d	DUP14	Duplicate 14th stack item	-	3
0x8e	DUP15	Duplicate 15th stack item	-	3
0x8f	DUP16	Duplicate 16th stack item	-	3
0x90	SWAP1	Exchange 1st and 2nd stack items	-	3
0x91	SWAP2	Exchange 1st and 3rd stack items	-	3
0x92	SWAP3	Exchange 1st and 4th stack items	-	3
0x93	SWAP4	Exchange 1st and 5th stack items	-	3
0x94	SWAP5	Exchange 1st and 6th stack items	-	3
0x95	SWAP6	Exchange 1st and 7th stack items	-	3
0x96	SWAP7	Exchange 1st and 8th stack items	-	3
0x97	SWAP8	Exchange 1st and 9th stack items	-	3
0x98	SWAP9	Exchange 1st and 10th stack items	-	3

Opcode	Name	Description	Extra info	Gas
0x99	SWAP10	Exchange 1st and 11th stack items	-	3
0x9a	SWAP11	Exchange 1st and 12th stack items	-	3
0x9b	SWAP12	Exchange 1st and 13th stack items	-	3
0x9c	SWAP13	Exchange 1st and 14th stack items	-	3
0x9d	SWAP14	Exchange 1st and 15th stack items	-	3
0x9e	SWAP15	Exchange 1st and 16th stack items	-	3
0x9f	SWAP16	Exchange 1st and 17th stack items	-	3
0xa0	LOG0	Append log record with no topics	-	375
0xa1	LOG1	Append log record with one topic	-	750
0xa2	LOG2	Append log record with two topics	-	1125
0xa3	LOG3	Append log record with three topics	-	1500
0xa4	LOG4	Append log record with four topics	-	1875
0xa5 - 0xaf	Unused	-	-	
0xb0	JUMPTO	Tentative <a href="#">libevmasm has different numbers</a>	<a href="#">EIP 615</a>	
0xb1	JUMPIF	Tentative	<a href="#">EIP-615</a>	
0xb2	JUMPSUB	Tentative	<a href="#">EIP-615</a>	
0xb4	JUMPSUBV	Tentative	<a href="#">EIP-615</a>	
0xb5	BEGINSUB	Tentative	<a href="#">EIP-615</a>	
0xb6	BEGINDATA	Tentative	<a href="#">EIP-615</a>	
0xb8	RETURNSUB	Tentative	<a href="#">EIP-615</a>	
0xb9	PUTLOCAL	Tentative	<a href="#">EIP-615</a>	
0xba	GETLOCA	Tentative	<a href="#">EIP-615</a>	
0xbb - 0xe0	Unused	-	-	



Opcode	Name	Description	Extra info	Gas
0xe1	SLOADBYTES	Only referenced in pyethereum	-	-
0xe2	SSTOREBYTES	Only referenced in pyethereum	-	-
0xe3	SSIZE	Only referenced in pyethereum	-	-
0xe4 - 0xef	Unused	-	-	
0xf0	CREATE	Create a new account with associated code	-	32000
0xf1	CALL	Message-call into an account	-	Complicated
0xf2	CALLCODE	Message-call into this account with alternative account's code	-	Complicated
0xf3	RETURN	Halt execution returning output data	-	0
0xf4	DELEGATECALL	Message-call into this account with an alternative account's code, but persisting into this account with an alternative account's code	-	Complicated
0xf5	CALLBLACKBOX	-	-	40
0xf6 - 0xf9	Unused	-	-	
0xfa	STATICCALL	Similar to CALL, but does not modify state	-	40
0xfb	CREATE2	Create a new account and set creation address to $\text{sha3}(\text{sender} + \text{sha3}(\text{init code})) \% 2^{*}160$	-	
0xfc	TXEXECGAS	Not in yellow paper FIXME	-	-

Opcode	Name	Description	Extra info	Gas
0xfd	REVERT	Stop execution and revert state changes, without consuming all provided gas and providing a reason	-	0
0xfe	INVALID	Designated invalid instruction	-	0
0xff	SELFDESTRUCT	Halt execution and register account for later deletion	-	5000*