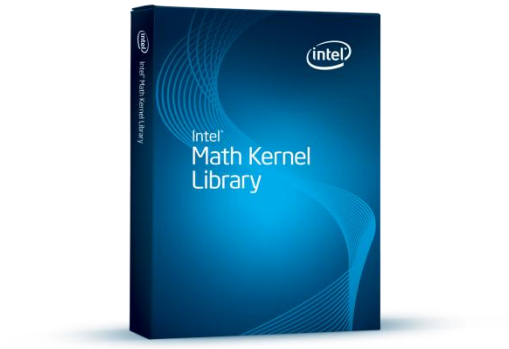
THE FLAGSHIP HIGH PERFORMANCE MATH LIBRARY FOR WINDOWS*, LINUX*, AND MAC OS* X

Intel® Math Kernel Library

Product Brief

Intel® Math Kernel Library 10.3
For Windows*, Linux* & Mac OS* X



"Intel MKL is indispensable for any high-performance computer user on x86 platforms."

Prof. Jack Dongarra, Innovative Computing Lab, University of Tennessee, Knoxville

"By adopting the Intel® MKL DGEMM libraries, our standard benchmarks timing improved between 43 percent and 71 percent..."

Matt Dunbar, Software Developer, ABAQUS, Inc.

Power science, engineering and financial applications with this highly optimized computing math library

- Multicore and multiprocessor ready
- Automatic parallelization
- Standard APIs in C and Fortran
- Royalty free redistribution

Intel® Math Kernel Library (Intel® MKL) is a library of highly optimized, extensively parallelized math routines that provides outstanding performance for scientific, engineering, and financial applications.

Mathematical Domains Supported by Intel® MKL

- Dense Linear Algebra - Basic Linear Algebra Subprograms (BLAS)*, Linear Algebra PACKage (LAPACK)*, Trust Region Solver
- Sparse Linear Algebra - Sparse BLAS, Sparse Format Converters, PARallel Direct Solver (PARDISO)*, Iterative Sparse Solvers (ISS) and Preconditioners
- Fast Fourier Transforms (FFT), including Fastest Fourier Transform in the West (FFTW)* interface
- Cluster Support - Scalable Linear Algebra PACKage (ScaLAPACK)*, Cluster Fast Fourier Transforms (Cluster FFT)
- Optimized LINPACK benchmark
- Vector Math Library (VML)
- Statistics Functions - Vector Statistical Library (VSL) and Summary Statistics Library (SSL)

Supported Mathematical Domains

Dense Linear Algebra

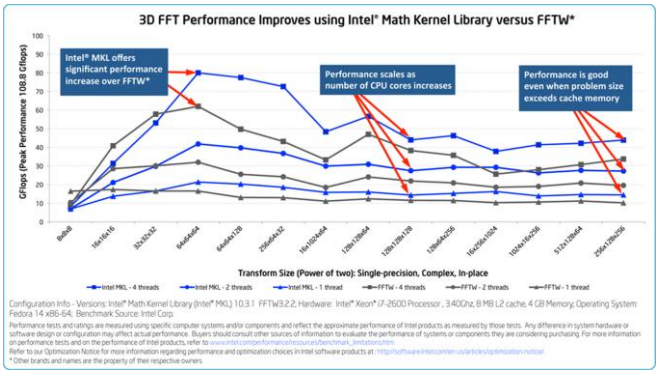
Intel MKL BLAS provides optimized vector-vector (Level 1), matrix-vector (Level 2) and matrix-matrix (Level 3) operations for single and double precision real and complex types. Level 1 BLAS routines operate on individual vectors, e.g., compute scalar product, norm, or the sum of vectors. Level 2 BLAS routines provide matrix-vector products, rank 1 and 2 updates of a matrix, and triangular system solvers. Level 3 BLAS level 3 routines include matrix-matrix products, rank k matrix updates, and triangular solvers with multiple right-hand sides.

Intel MKL LAPACK provides extremely well-tuned LU, Cholesky, and QR factorization and driver routines that can be used to solve linear systems of equations. Eigenvalue and least-squares solvers are also included, as are the latest LAPACK 3.3.1 interfaces and enhancements.

If your application already relies on the BLAS or LAPACK functionality, simply re-link with Intel® MKL to get better performance on Intel and Intel compatible architectures.

Fast Fourier Transforms

Intel MKL FFTs include many optimizations and should provide significant performance gains over other libraries for medium and large transform sizes. The library supports a broad variety of FFTs, from single and double precision 1D to multi-dimensional, complex-to-complex, real-to-complex, and real-to-real transforms of arbitrary length. Support for both Intel® DFTI and FFTW* interfaces simplifies the porting of your FFT-based applications.



View additional benchmarks at
http://software.intel.com/en-us/articles/intel-mkl/#details

Vector Math Library

Intel MKL Vector Math Library (VML) provides optimized vector implementations of computationally intensive core mathematical operations and functions for single and double precision real and complex types. The basic vector arithmetic operations include element-by-element summation, subtraction, multiplication, division, and conjugation as well as rounding operations such as floor, ceil, and round to the nearest integer. Additional functions include power, square root, inverse, logarithm, trigonometric, hyperbolic, (inverse) error and cumulative normal distribution, and pack/unpack. Enhanced capabilities of Intel® MKL VML include accuracy, denormalized number handling, and error mode controls, allowing users to customize the behavior to meet their individual needs.

Real Functions						
Trigonometric	Hyperbolic	Power, Root	Exponential, Logarithmic	Arithmetic	Rounding	Special
Acos	Acosh	Cbrt	Exp	Abs	Ceil	CdfNorm
Asin	Asinh	Hypot	Expm1	Add	Floor	CdfNormInv
Atan	Atanh	Inv	Ln	Div	Modf	Erf
Atan2	Cosh	InvCbrt	Log10	LinearFrac	NearbyInt	Erfc
Cos	Sinh	InvSqrt	Log1p	Mul	Rint	ErfInv
Sin	Tanh	Pow		Sqr	Round	ErfcInv
SinCos		Powx		Sub	Trunc	LGamma
Tan		Pow2o3				TGamma
		Pow3o2				
		Sqrt				

Complex Functions				
Trigonometric	Hyperbolic	Power, Root	Exponential, Logarithmic	Arithmetic
Acos	Acosh	Pow	Exp	Abs
Asin	Asinh	Powx	Ln	Add
Atan	Atanh	Sqrt	Log10	Arg
CIS	Cosh			Conj
Cos	Sinh			Div
Sin	Tanh			Mul
Tan				MulByConj
				Sub

Statistics Functions

- Intel MKL Vector Statistical Library (VSL) includes random number generators and probability distributions that can deliver significant performance improvements for physics, chemistry, and financial analysis applications. The functions provide the user the ability to pair Random-Number Generators such as Mersenne Twister and, Niederreiter with a variety of Probability Distributions including Uniform, Gaussian and Exponential.
- Intel MKL Summary Statistics Library (SSL) provides computationally intensive core/building blocks for statistical analysis both in and out-of-core. This library enables users to compute basic statistics, estimation of dependencies, data outlier detection, and missing value replacements. These features can be used to speed-up applications in computational finance, life sciences, engineering/simulations, databases, and other areas.

Random Number Generators
Pseudo-Random
Multiplicative Congruential 59-Bit
Multiplicative Congruential 31-Bit
Multiple Recursive
Feedback Shift Register
Feedback Shift Register
Wichman-Hill
Mersenne Twister 19937
Mersenne Twister 2203
Quasi-Random
Sobol
Niederreiter

Probability Distributions	
Continuous	Discrete
Uniform	Uniform
Gaussian (ICDF)	UniformBits
Gaussian (BOXMULLER)	Bernoulli
Gaussian (BOXMULLER2)	Geometric
GaussianMV (ICDF)	Binomial
GaussianMV (BOXMULLER)	Hypergeometric
GaussianMV (BOXMULLER2)	Poisson (PTPE)
Exponential	Poisson(POISNORM)
Laplace	PoissonV
Weibull	NegBinomial
Cauchy	
Rayleigh	
Lognormal	
Gumbel	
Gamma	
Beta	

Sparse Linear Algebra

Intel MKL Sparse BLAS includes optimized functions to operate on sparse matrices and vectors. Support is provided for scalar products, matrix-vector and matrix-matrix multiplications in the most popular sparse matrix storage formats – coordinate (COO), compressed sparse row (CSR), compressed sparse column (CSC), diagonal (DIA), skyline (SKY), block sparse row (BSR) - and functions to convert between storage formats. Intel MKL Sparse Solvers include both direct and iterative methods to solve large sparse linear systems of equations. Intel MKL PARDISO is an optimized, robust memory efficient direct solver for large sparse linear systems that may arise from Finite Element or Finite Difference approximations. Support for both single and double precision real and complex input arrays is included. An out-of-core mode enables users to solve larger systems that do not fit in local memory. A collection of iterative solvers are also available. The Flexible Generalized Minimal RESidual (FGMRES)* and Conjugate Gradient (CG) solvers allow users to solve general and symmetric positive definite sparse linear systems of equations.

Cluster support

- Intel MKL ScaLAPACK contains highly optimized linear algebra functions suitable for distributed memory computing on clusters. The interfaces are fully compatible with the NETLIB* interfaces. The pre-built interfaces eliminate the heavy-lifting required to build this complex cluster software component.
- Intel MKL Cluster FFT provides optimized support for distributed memory FFTs. Computing a Fast Fourier Transform of size 240 is no longer an impossible task with Cluster FFT.
- Unleash the power of your cluster by linking your applications with Intel® MKL.
- Standard LINPACK benchmark
- The Intel MKL package includes optimized implementations of the standard LINPACK* benchmark for both SMP (symmetric multiprocessing) and MP (distributed memory clusters). Use these benchmarks to measure the performance of Intel processor-based systems.

Features

Feature	Benefit
Performance	
Enhanced Performance	Includes optimizations for Intel's latest generation of processors and helps users utilize performance enhancing features such as Intel® Advanced Vector Extensions (Intel® AVX).
Automatic Parallelization	Automatically increases application performance on multi-core processors without additional effort.
Support for Multicore Processors	Much of Intel MKL is threaded to help you get the most of today's multi-core processors. Intel MKL functions are also fully thread-safe, so multiple calls for different threads will not conflict with one another. See below for a complete list of supported CPU's.
Cluster Support	Scale your application on clusters using routines such as Cluster FFTs, Parallel BLAS (PBLAS) and Scalable LAPACK (ScaLAPACK).
Instruction Set Level Optimizations	Functions deliver performance beyond what optimizing compilers alone can deliver. For each Intel Architecture compatible processor, MKL dispatches code to take advantage of the underlying hardware features including SIMD instructions. For detailed performance data, visit the Intel MKL product web page at http://www.intel.com/software/products/mkl
Productivity	
Rich Functionality	Broad support for dense Linear Algebra, Sparse Linear Algebra, Fast Fourier Transforms, Optimized LINPACK benchmark, Vector Math Library, Statistics Functions including Random Number Generators (RNG) and Cluster Support that help speed your application development.
C/C++, Fortran Support	Built-in API's to support your language of choice.
C#, .NET, Java Usage Samples	C#, .NET and Java environments supported with code wrapper examples that ease integration.
Future Proofing	
Supports future processor enhancements	Optimized for current multicore and future manycore processors. At the introduction of the new Intel CPU's, just re-link with the latest version of Intel MKL to achieve the greater application performance.
Simple Licensing	
Royalty-free Redistribution	Redistribute unlimited copies of the runtime libraries with your application.
Attractive Product Pricing	Affordable starting at US$399, special academic pricing is also available.
New Features in MKL 10.3	
Support for Intel® AVX	New performance optimizations for Intel AVX results in faster floating point operations in the BLAS, LAPACK, FFTs, VML, and VSL functional domains for Intel® Core™ 2 Processors and later processors.
Summary Statistics Library	New functions covering basic statistics, covariance and correlation, pooled, group, partial, and robust covariance/correlation, quantiles and streaming quantiles, outliers detection algorithm, and missing values.
C Extensions for LAPACK and PARDISO	New C interfaces for all LAPACK functions supporting row-major ordering. Support for c-style (zero-based) array indexing for PARDISO data arrays.
Dynamic Accuracy Control in VML	New interfaces for each VML function including additional parameter for setting the accuracy mode.
Additional optimizations	Optimizations and enhanced capabilities across many MKL domains, PARDISO, FFTs, and VSL.

Purchase Options: Language Specific Suites

Several suites are available combining the tools to build, verify and tune your application. The products covered in this product brief are highlighted in green. Single or multi-user licenses and volume, academic, and student discounts are available.

	Suites >>	Intel® Parallel Studio XE	Intel® C++ Studio XE	Intel® Fortran Studio XE	Intel® Composer XE	Intel® C++ Composer XE	Intel® Fortran Composer XE	Intel® Cluster Studio XE	Intel® Cluster Studio
Components	Intel® C / C++ Compiler	●	●		●	●		●	●
	Intel® Fortran Compiler	●		●	●		●	●	●
	Intel® Integrated Performance Primitives[3]	●	●		●	●		●	●
	Intel® Math Kernel Library[3]	●	●	●	●	●	●	●	●
	Intel® Cilk™ Plus	●	●		●	●		●	●
	Intel® Threading Building Blocks	●	●		●	●		●	●
	Intel® Inspector XE	●	●	●				●	
	Intel® VTune™ Amplifier XE	●	●	●				●	
	Static Security Analysis	●	●	●				●	
	Intel® MPI Library							●	●
	Intel® Trace Analyzer & Collector							●	●
	Rogue Wave IMSL* Library[2]						●		
	Operating System[1]	W, L	W, L	W, L	W, L	W, L, M	W, L, M	W, L	W, L

Note: (1)[1] Operating System: W=Windows, L= Linux, M= Mac OS* X. (2)[2] Available in Intel® Visual Fortran Composer XE for Windows with IMSL*
(3)[3] Not available individually on Mac OS X, it is included in Intel® C++ & Fortran Composer XE suites for Mac OS X

Technical Specifications	
Processor support	Validated for use with multiple generations of Intel and compatible processors including but not limited to Intel® Xeon™, Intel® Core™, Intel® Core™ i3, Intel® Core™ i5, and Intel® Core™ i7 processor families.
Operating systems	Use the same API for application development on multiple operating systems - Windows*, Linux* and MAC OS* X
Programming languages	Fully compatible with all development tools from Intel such as compilers, performance and threading analyzers, and other Intel® Performance Libraries. In addition, Intel® MKL is easily used and integrated with popular development tools and environments such as Microsoft Visual Studio* (2005, 2008, 2010), Xcode*, Eclipse*, and the GNU Compiler Collection* (GCC*).
Programming Languages	Natively supports FORTRAN, C, and C++ development; cross language usage examples provided for C#/.NET* and Java*.
System requirements	Please refer to www.intel.com/software/products/systemrequirements/ for details on hardware and software requirements.
Support	All product updates, Intel® Premier Support services and Intel® Support Forums are included for one year. Intel Premier Support gives you confidential support, technical notes, application notes, and the latest documentation. Join the Intel® Support Forums community to learn, contribute, or just browse! http://software.intel.com/en-us/forums.

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Optimization Notice

Notice revision #20110804

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.