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Portable Document Format (PDF), standardized as ISO 32000, is a file format developed by Adobe in 1992 to present documents, including text formatting and images, in a manner independent of application software, hardware, and operating systems. Based on the PostScript language, each PDF file encapsulates a complete description of a fixed-layout flat document, including the text, fonts, vector graphics, raster images and other information needed to display it. PDF has its roots in "The Camelot Project" initiated by Adobe co-founder John Warnock in 1991. PDF was standardized as ISO 32000 in 2008. The last edition as ISO 32000-2:2020 was published in December 2020. PDF files may contain a variety of content besides flat text and graphics including logical structuring elements, interactive elements such as annotations and form-fields, layers, rich media (including video content), three-dimensional objects using U3D or PRC, and various other data formats. The PDF specification also provides for encryption and digital signatures, file attachments, and metadata to enable workflows requiring these features. History Main article: History of PDF Adobe Systems made the PDF specification available free of charge in 1993. In the early years PDF was popular mainly in desktop publishing workflows, and competed with a variety of formats such as DjVu, Envoy, Common Ground Digital Paper, Farallon Replica and even Adobe's own PostScript format. PDF was a proprietary format controlled by Adobe until it was released as an open standard on July 1, 2008, and published by the International Organization for Standardization as ISO 32000-1:2008, at which time control of the specification passed to an ISO Committee of volunteer industry experts. In 2008, Adobe published a Public Patent License to ISO 32000-1 granting royalty-free rights for all patents owned by Adobe that are necessary to make, use, sell, and distribute PDF-compliant implementations. PDF 1.7, the sixth edition of the PDF specification that became ISO 32000-1, includes some proprietary technologies defined only by Adobe, such as Adobe XML Forms Architecture (XFA) and JavaScript extension for Acrobat, which are referenced by ISO 32000-1 as normative and indispensable for the full implementation of the ISO 32000-1 specification. These proprietary technologies are not standardized and their specification is published only on Adobe's website. Many of them are also not

supported by popular third-party implementations of PDF. In December 2020, the second edition of PDF 2.0, ISO 32000-2:2020, was published, including clarifications, corrections, and critical updates to normative references. ISO 32000-2 does not include any proprietary technologies as normative references. ISO's publication of ISO 32000-2 in 2017 ended the 24-year tradition of the latest PDF specification being freely available from Adobe. Starting in April, 2023, to provide PDF developers and stakeholders with their accustomed level of access, the PDF Association and its sponsors made ISO 32000-2 available for download at no cost. Technical details A PDF file is often a combination of vector graphics, text, and bitmap graphics. The basic types of content in a PDF are: Typeset text stored as content streams (i.e., not encoded in plain text); Vector graphics for illustrations and designs that consist of shapes and lines; Raster graphics for photographs and other types of images Multimedia objects in the document. In later PDF revisions, a PDF document can also support links (inside document or web page), forms, JavaScript (initially available as a plugin for Acrobat 3.0), or any other types of embedded contents that can be handled using plug-ins. PDF combines three technologies: An equivalent subset of the PostScript page description programming language but in declarative form, for generating the layout and graphics. A font-embedding/replacement system to allow fonts to travel with the documents. A structured storage system to bundle these elements and any associated content into a single file, with data compression where appropriate. PostScript language PostScript is a page description language run in an interpreter to generate an image, a process requiring many resources. It can handle graphics and standard features of programming languages such as if statements and loop commands. PDF is largely based on PostScript but simplified to remove flow control features like these, while graphics commands equivalent to lineto remain. Historically, the PostScript-like PDF code is generated from a source PostScript file. The graphics commands that are output by the PostScript code are collected and tokenized.[clarification needed] Any files, graphics, or fonts to which the document refers also are collected. Then, everything is compressed to a single file. Therefore, the entire PostScript world (fonts, layout, measurements) remains intact.[citation needed] As a document format, PDF has several advantages over PostScript: PDF contains tokenized and interpreted results of the PostScript source code, for direct correspondence between changes to items in the PDF page description and changes to the resulting page

appearance. PDF (since version 1.4) supports transparent graphics; PostScript does not. PostScript is an interpreted programming language with an implicit global state, so instructions accompanying the description of one page can affect the appearance of any following page. Therefore, all preceding pages in a PostScript document must be processed to determine the correct appearance of a given page, whereas each page in a PDF document is unaffected by the others. As a result, PDF viewers allow the user to quickly jump to the final pages of a long document, whereas a PostScript viewer needs to process all pages sequentially before being able to display the destination page (unless the optional PostScript Document Structuring Conventions have been carefully compiled and included). PDF 1.6 and later supports interactive 3D documents embedded in a PDF file: 3D drawings can be embedded using U3D or PRC and various other data formats. File format A PDF file is organized using ASCII characters, except for certain elements that may have binary content. The file starts with a header containing a magic number (as a readable string) and the version of the format, for example %PDF-1.7. The format is a subset of a COS ("Carousel" Object Structure) format. A COS tree file consists primarily of objects, of which there are nine types: Boolean values, representing true or false Real numbers Integers Strings, enclosed within parentheses ((...)) or represented as hexadecimal within single angle brackets (<...>). Strings may contain 8-bit characters. Names, starting with a forward slash (/) Arrays, ordered collections of objects enclosed within square brackets ([...]) Dictionaries, collections of objects indexed by names enclosed within double angle brackets (<<...>>) Streams, usually containing large amounts of optionally compressed binary data, preceded by a dictionary and enclosed between the stream and endstream keywords. The null object Furthermore, there may be comments, introduced with the percent sign (%). Comments may contain 8-bit characters. Objects may be either direct (embedded in another object) or indirect. Indirect objects are numbered with an object number and a generation number and defined between the obj and endobj keywords if residing in the document root. Beginning with PDF version 1.5, indirect objects (except other streams) may also be located in special streams known as object streams (marked /Type /ObjStm). This technique enables non-stream objects to have standard stream filters applied to them, reduces the size of files that have large numbers of small indirect objects and is especially useful for Tagged PDF. Object streams do not support specifying an object's generation number (other than 0). An index table, also called the cross-

reference table, is located near the end of the file and gives the byte offset of each indirect object from the start of the file. This design allows for efficient random access to the objects in the file, and also allows for small changes to be made without rewriting the entire file (incremental update). Before PDF version 1.5, the table would always be in a special ASCII format, be marked with the xref keyword, and follow the main body composed of indirect objects. Version 1.5 introduced optional cross-reference streams, which have the form of a standard stream object, possibly with filters applied. Such a stream may be used instead of the ASCII cross-reference table and contains the offsets and other information in binary format. The format is flexible in that it allows for integer width specification (using the /W array), so that for example, a document not exceeding 64 KiB in size may dedicate only 2 bytes for object offsets. At the end of a PDF file is a footer containing The startxref keyword followed by an offset to the start of the cross-reference table (starting with the xref keyword) or the cross-reference stream object, followed by The %%EOF end-of-file marker. If a cross-reference stream is not being used, the footer is preceded by the trailer keyword followed by a dictionary containing information that would otherwise be contained in the cross-reference stream object's dictionary: A reference to the root object of the tree structure, also known as the catalog (/Root) The count of indirect objects in the cross-reference table (/Size) Other optional information Within each page, there are one or multiple content streams that describe the text, vector and images being drawn on the page. The content stream is stack-based, similar to PostScript. The maximum size of a PDF compared to Europe. There are two layouts to the PDF files: non-linearized (not "optimized") and linearized ("optimized"). Non-linearized PDF files can be smaller than their linear counterparts, though they are slower to access because portions of the data required to assemble pages of the document are scattered throughout the PDF file. Linearized PDF files (also called "optimized" or "web optimized" PDF files) are constructed in a manner that enables them to be read in a Web browser plugin without waiting for the entire file to download, since all objects required for the first page to display are optimally organized at the start of the file. PDF files may be optimized using Adobe Acrobat software or QPDF. Page dimensions are not limited by the format itself. However, Adobe Acrobat imposes a limit of 15 million in by 15 million in, or 225 trillion in2 (145,161 km2). Imaging model The basic design of how graphics are represented in PDF is very similar to that of PostScript, except for the use of transparency, which was added in PDF 1.4. PDF graphics use a device-independent Cartesian

coordinate system to describe the surface of a page. A PDF page description can use a matrix to scale, rotate, or skew graphical elements. A key concept in PDF is that of the graphics state, which is a collection of graphical parameters that may be changed, saved, and restored by a page description. PDF has (as of version 2.0) 25 graphics state properties, of which some of the most important are: The current transformation matrix (CTM), which determines the coordinate system The clipping path The color space The alpha constant, which is a key component of transparency Black point compensation control (introduced in PDF 2.0) Vector graphics As in PostScript, vector graphics in PDF are constructed with paths. Paths are usually composed of lines and cubic Bézier curves, but can also be constructed from the outlines of text. Unlike PostScript, PDF does not allow a single path to mix text outlines with lines and curves. Paths can be stroked, filled, fill then stroked, or used for clipping. Strokes and fills can use any color set in the graphics state, including patterns. PDF supports several types of patterns. The simplest is the tiling pattern in which a piece of artwork is specified to be drawn repeatedly. This may be a colored tiling pattern, with the colors specified in the pattern object, or an uncolored tiling pattern, which defers color specification to the time the pattern is drawn. Beginning with PDF 1.3 there is also a shading pattern, which draws continuously varying colors. There are seven types of shading patterns of which the simplest are the axial shading (Type 2) and radial shading (Type 3). Raster images Raster images in PDF (called Image XObjects) are represented by dictionaries with an associated stream. The dictionary describes the properties of the image, and the stream contains the image data. (Less commonly, small raster images may be embedded directly in a page description as an inline image.) Images are typically filtered for compression purposes. Image filters supported in PDF include the following general-purpose filters: ASCII85Decode, a filter used to put the stream into 7-bit ASCII, ASCIIHexDecode, similar to ASCII85Decode but less compact, FlateDecode, a commonly used filter based on the deflate algorithm defined in RFC 1951 (deflate is also used in the gzip, PNG, and zip file formats among others); introduced in PDF 1.2; it can use one of two groups of predictor functions for more compact zlib/deflate compression: Predictor 2 from the TIFF 6.0 specification and predictors (filters) from the PNG specification (RFC 2083), LZWDecode, a filter based on LZW Compression; it can use one of two groups of predictor functions for more compact LZW compression: Predictor 2 from the TIFF 6.0 specification and predictors (filters) from the

PNG specification, RunLengthDecode, a simple compression method for streams with repetitive data using the run-length encoding algorithm and the image-specific filters, DCTDecode, a lossy filter based on the JPEG standard, CCITTFaxDecode, a lossless bi-level (black/white) filter based on the Group 3 or Group 4 CCITT (ITU-T) fax compression standard defined in ITU-T T.4 and T.6, JBIG2Decode, a lossy or lossless bi-level (black/white) filter based on the JBIG2 standard, introduced in PDF 1.4, and JPXDecode, a lossy or lossless filter based on the JPEG 2000 standard, introduced in PDF 1.5. Normally all image content in a PDF is embedded in the file. But PDF allows image data to be stored in external files by the use of external streams or Alternate Images. Standardized subsets of PDF, including PDF/A and PDF/X, prohibit these features. Text Text in PDF is represented by text elements in page content streams. A text element specifies that characters should be drawn at certain positions. The characters are specified using the encoding of a selected font resource. A font object in PDF is a description of a digital typeface. It may either describe the characteristics of a typeface, or it may include an embedded font file. The latter case is called an embedded font while the former is called an unembedded font. The font files that may be embedded are based on widely used standard digital font formats: Type 1 (and its compressed variant CFF), TrueType, and (beginning with PDF 1.6) OpenType. Additionally PDF supports the Type 3 variant in which the components of the font are described by PDF graphic operators. Fourteen typefaces, known as the standard 14 fonts, have a special significance in PDF documents: Times (v3) (in regular, italic, bold, and bold italic) Courier (in regular, oblique, bold and bold oblique) Helvetica (v3) (in regular, oblique, bold and bold oblique) Symbol Zapf Dingbats These fonts are sometimes called the base fourteen fonts. These fonts, or suitable substitute fonts with the same metrics, should be available in most PDF readers, but they are not guaranteed to be available in the reader, and may only display correctly if the system has them installed. Fonts may be substituted if they are not embedded in a PDF. Within text strings, characters are shown using character codes (integers) that map to glyphs in the current font using an encoding. There are several predefined encodings, including WinAnsi, MacRoman, and many encodings for East Asian languages and a font can have its own built-in encoding. (Although the WinAnsi and MacRoman encodings are derived from the historical properties of the Windows and Macintosh operating systems, fonts using these encodings work

equally well on any platform.) PDF can specify a predefined encoding to use, the font's built-in encoding or provide a lookup table of differences to a predefined or built-in encoding (not recommended with TrueType fonts). The encoding mechanisms in PDF were designed for Type 1 fonts, and the rules for applying them to TrueType fonts are complex. For large fonts or fonts with non-standard glyphs, the special encodings Identity-H (for horizontal writing) and Identity-V (for vertical) are used. With such fonts, it is necessary to provide a ToUnicode table if semantic information about the characters is to be preserved. Transparency The original imaging model of PDF was, like PostScript's, opaque: each object drawn on the page completely replaced anything previously marked in the same location. In PDF 1.4 the imaging model was extended to allow transparency. When transparency is used, new objects interact with previously marked objects to produce blending effects. The addition of transparency to PDF was done by means of new extensions that were designed to be ignored in products written to PDF 1.3 and earlier specifications. As a result, files that use a small amount of transparency might view acceptably by older viewers, but files making extensive use of transparency could be viewed incorrectly by an older viewer. The transparency extensions are based on the key concepts of transparency groups, blending modes, shape, and alpha. The model is closely aligned with the features of Adobe Illustrator version 9. The blend modes were based on those used by Adobe Photoshop at the time. When the PDF 1.4 specification was published, the formulas for calculating blend modes were kept secret by Adobe. They have since been published. The concept of a transparency group in PDF specification is independent of existing notions of "group" or "layer" in applications such as Adobe Illustrator. Those groupings reflect logical relationships among objects that are meaningful when editing those objects, but they are not part of the imaging model. Additional features Logical structure and accessibility A "tagged" PDF (see clause 14.8 in ISO 32000) includes document structure and semantics information to enable reliable text extraction and accessibility. Technically speaking, tagged PDF is a stylized use of the format that builds on the logical structure framework introduced in PDF 1.3. Tagged PDF defines a set of standard structure types and attributes that allow page content (text, graphics, and images) to be extracted and reused for other purposes. Tagged PDF is not required in situations where a PDF file is intended only for print. Since the feature is optional, and since the rules for Tagged PDF were relatively vague in

ISO 32000-1, support for tagged PDF among consuming devices, including assistive technology (AT), is uneven as of 2021. ISO 32000-2, however, includes an improved discussion of tagged PDF which is anticipated to facilitate further adoption. An ISO-standardized subset of PDF specifically targeted at accessibility, PDF/UA, was first published in 2012. Optional Content Groups (layers) With the introduction of PDF version 1.5 (2003) came the concept of Layers. Layers, more formally known as Optional Content Groups (OCGs), refer to sections of content in a PDF document that can be selectively viewed or hidden by document authors or viewers. This capability is useful in CAD drawings, layered artwork, maps, multi-language documents, etc. Basically, it consists of an Optional Content Properties Dictionary added to the document root. This dictionary contains an array of Optional Content Groups (OCGs), each describing a set of information and each of which may be individually displayed or suppressed, plus a set of Optional Content Configuration Dictionaries, which give the status (Displayed or Suppressed) of the given OCGs. Encryption and signatures A PDF file may be encrypted, for security, in which case a password is needed to view or edit the contents. PDF 2.0 defines 256-bit AES encryption as standard for PDF 2.0 files. The PDF Reference also defines ways that third parties can define their own encryption systems for PDF. PDF files may be digitally signed, to provide secure authentication; complete details on implementing digital signatures in PDF is provided in ISO 32000-2. PDF files may also contain embedded DRM restrictions that provide further controls that limit copying, editing, or printing. These restrictions depend on the reader software to obey them, so the security they provide is limited. The standard security provided by PDF consists of two different methods and two different passwords: a user password, which encrypts the file and prevents opening, and an owner password, which specifies operations that should be restricted even when the document is decrypted, which can include modifying, printing, or copying text and graphics out of the document, or adding or modifying text notes and AcroForm fields. The user password encrypts the file, while the owner password does not, instead relying on client software to respect these restrictions. An owner password can easily be removed by software, including some free online services. Thus, the use restrictions that a document author places on a PDF document are not secure, and cannot be assured once the file is distributed; this warning is displayed when applying such restrictions using Adobe Acrobat software to create or edit PDF files. Even without removing the password, most freeware or open source

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the names and values of selected interactive form fields to a specified uniform resource locator (URL). Interactive form field names and values may be submitted in any of the following formats, (depending on the settings of the action's ExportFormat, SubmitPDF, and XFDF flags): HTML Form format HTML 4.01 Specification since PDF 1.5; HTML 2.0 since 1.2 Forms Data Format (FDF) based on PDF, uses the same syntax and has essentially the same file structure, but is much simpler than PDF since the body of an FDF document consists of only one required object. Forms Data Format is defined in the PDF specification (since PDF 1.2). The Forms Data Format can be used when submitting form data to a server, receiving the response, and incorporating it into the interactive form. It can also be used to export form data to stand-alone files that can be imported back into the corresponding PDF interactive form. FDF was originally defined in 1996 as part of ISO 32000-2:2017.[citation needed] XML Forms Data Format (XFDF) (external XML Forms Data Format Specification, Version 2.0; supported since PDF 1.5; it replaced the "XML" form submission format defined in PDF 1.4) the XML version of Forms Data Format, but the XFDF implements only a subset of FDF containing forms and annotations. Some entries in the FDF dictionary do not have XFDF equivalents – such as the Status, Encoding, JavaScript, Page's keys, EmbeddedFDFs, Differences, and Target. In addition, XFDF does not allow the spawning, or addition, of new pages based on the given data; as can be done when using an FDF file. The XFDF specification is referenced (but not included) in PDF 1.5 specification (and in later versions). It is described separately in XML Forms Data Format Specification. The PDF 1.4 specification allowed form submissions in XML format, but this was replaced by submissions in XFDF format in the PDF 1.5 specification. XFDF conforms to the XML standard. XFDF can be used in the same way as FDF; e.g., form data is submitted to a server, modifications are made, then sent back and the new form data is imported in an interactive form. It can also be used to export form data to stand-alone files that can be imported back into the corresponding PDF interactive form. As of August 2019, XFDF 3.0 is an ISO/IEC standard under the formal name ISO 19444-1:2019 - Document management — XML Forms Data Format — Part 1: Use of ISO 32000-2 (XFDF 3.0). This standard is a normative reference of ISO 32000-2. PDF The entire document can be submitted rather than individual fields and values, as was defined in PDF 1.4. AcroForms can keep form field values in external stand-alone files containing key-value pairs. The external files may use Forms Data Format (FDF) and XML

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ISO 32000-1 granting royalty-free rights for all patents owned by Adobe that are necessary to make, use, sell, and distribute PDF-compliant implementations. PDF 1.7, the sixth edition of the PDF specification that became ISO 32000-1, includes some proprietary technologies defined only by Adobe, such as Adobe XML Forms Architecture (XFA) and JavaScript extension for Acrobat, which are referenced by ISO 32000-1 as normative and indispensable for the full implementation of the ISO 32000-1 specification. These proprietary technologies are not standardized and their specification is published only on Adobe's website. Many of them are also not supported by popular third-party implementations of PDF. In December 2020, the second edition of PDF 2.0, ISO 32000-2:2020, was published, including clarifications, corrections, and critical updates to normative references. ISO 32000-2 does not include any proprietary technologies as normative references. ISO's publication of ISO 32000-2 in 2017 ended the 24-year tradition of the latest PDF specification being freely available from Adobe. Starting in April, 2023, to provide PDF developers and stakeholders with their accustomed level of access, the PDF Association and its sponsors made ISO 32000-2 available for download at no cost. Technical details A PDF file is often a combination of vector graphics, text, and bitmap graphics. The basic types of content in a PDF are: Typeset text stored as content streams (i.e., not encoded in plain text); Vector graphics for illustrations and designs that consist of shapes and lines; Raster graphics for photographs and other types of images Multimedia objects in the document. In later PDF revisions, a PDF document can also support links (inside document or web page), forms, JavaScript (initially available as a plugin for Acrobat 3.0), or any other types of embedded contents that can be handled using plug-ins. PDF combines three technologies: An equivalent subset of the PostScript page description programming language but in declarative form, for generating the layout and graphics. A font-embedding/replacement system to allow fonts to travel with the documents. A structured storage system to bundle these elements and any associated content into a single file, with data compression where appropriate. PostScript language PostScript is a page description language run in an interpreter to generate an image, a process requiring many resources. It can handle graphics and standard features of programming languages such as if statements and loop commands. PDF is largely based on PostScript but simplified to remove flow control features like these, while graphics commands equivalent to lineto remain. Historically, the PostScript-like PDF code is generated from a

source PostScript file. The graphics commands that are output by the PostScript code are collected and tokenized.[clarification needed] Any files, graphics, or fonts to which the document refers also are collected. Then, everything is compressed to a single file. Therefore, the entire PostScript world (fonts, layout, measurements) remains intact.[citation needed] As a document format, PDF has several advantages over PostScript: PDF contains tokenized and interpreted results of the PostScript source code, for direct correspondence between changes to items in the PDF page description and changes to the resulting page appearance. PDF (since version 1.4) supports transparent graphics; PostScript does not. PostScript is an interpreted programming language with an implicit global state, so instructions accompanying the description of one page can affect the appearance of any following page. Therefore, all preceding pages in a PostScript document must be processed to determine the correct appearance of a given page, whereas each page in a PDF document is unaffected by the others. As a result, PDF viewers allow the user to quickly jump to the final pages of a long document, whereas a PostScript viewer needs to process all pages sequentially before being able to display the destination page (unless the optional PostScript Document Structuring Conventions have been carefully compiled and included). PDF 1.6 and later supports interactive 3D documents embedded in a PDF file: 3D drawings can be embedded using U3D or PRC and various other data formats. File format A PDF file is organized using ASCII characters, except for certain elements that may have binary content. The file starts with a header containing a magic number (as a readable string) and the version of the format, for example %PDF-1.7. The format is a subset of a COS ("Carousel" Object Structure) format. A COS tree file consists primarily of objects, of which there are nine types: Boolean values, representing true or false Real numbers Integers Strings, enclosed within parentheses ((...)) or represented as hexadecimal within single angle brackets (<...>). Strings may contain 8-bit characters. Names, starting with a forward slash (/) Arrays, ordered collections of objects enclosed within square brackets ([...]) Dictionaries, collections of objects indexed by names enclosed within double angle brackets (<<...>>) Streams, usually containing large amounts of optionally compressed binary data, preceded by a dictionary and enclosed between the stream and endstream keywords. The null object Furthermore, there may be comments, introduced with the percent sign (%). Comments may contain 8-bit characters. Objects may be either direct (embedded in another object) or indirect. Indirect

objects are numbered with an object number and a generation number and defined between the obj and endobj keywords if residing in the document root. Beginning with PDF version 1.5, indirect objects (except other streams) may also be located in special streams known as object streams (marked /Type /ObjStm). This technique enables non-stream objects to have standard stream filters applied to them, reduces the size of files that have large numbers of small indirect objects and is especially useful for Tagged PDF. Object streams do not support specifying an object's generation number (other than 0). An index table, also called the cross-reference table, is located near the end of the file and gives the byte offset of each indirect object from the start of the file. This design allows for efficient random access to the objects in the file, and also allows for small changes to be made without rewriting the entire file (incremental update). Before PDF version 1.5, the table would always be in a special ASCII format, be marked with the xref keyword, and follow the main body composed of indirect objects. Version 1.5 introduced optional cross-reference streams, which have the form of a standard stream object, possibly with filters applied. Such a stream may be used instead of the ASCII cross-reference table and contains the offsets and other information in binary format. The format is flexible in that it allows for integer width specification (using the /W array), so that for example, a document not exceeding 64 KiB in size may dedicate only 2 bytes for object offsets. At the end of a PDF file is a footer containing The startxref keyword followed by an offset to the start of the cross-reference table (starting with the xref keyword) or the cross-reference stream object, followed by The %%EOF end-of-file marker. If a cross-reference stream is not being used, the footer is preceded by the trailer keyword followed by a dictionary containing information that would otherwise be contained in the cross-reference stream object's dictionary: A reference to the root object of the tree structure, also known as the catalog (/Root) The count of indirect objects in the cross-reference table (/Size) Other optional information Within each page, there are one or multiple content streams that describe the text, vector and images being drawn on the page. The content stream is stack-based, similar to PostScript. The maximum size of a PDF compared to Europe. There are two layouts to the PDF files: non-linearized (not "optimized") and linearized ("optimized"). Non-linearized PDF files can be smaller than their linear counterparts, though they are slower to access because portions of the data required to assemble pages of the document are scattered throughout the PDF file. Linearized PDF files (also called "optimized" or "web optimized" PDF files) are constructed in a manner

that enables them to be read in a Web browser plugin without waiting for the entire file to download, since all objects required for the first page to display are optimally organized at the start of the file. PDF files may be optimized using Adobe Acrobat software or QPDF. Page dimensions are not limited by the format itself. However, Adobe Acrobat imposes a limit of 15 million in by 15 million in, or 225 trillion in2 (145,161 km2). Imaging model The basic design of how graphics are represented in PDF is very similar to that of PostScript, except for the use of transparency, which was added in PDF 1.4. PDF graphics use a device-independent Cartesian coordinate system to describe the surface of a page. A PDF page description can use a matrix to scale, rotate, or skew graphical elements. A key concept in PDF is that of the graphics state, which is a collection of graphical parameters that may be changed, saved, and restored by a page description. PDF has (as of version 2.0) 25 graphics state properties, of which some of the most important are: The current transformation matrix (CTM), which determines the coordinate system The clipping path The color space The alpha constant, which is a key component of transparency Black point compensation control (introduced in PDF 2.0) Vector graphics As in PostScript, vector graphics in PDF are constructed with paths. Paths are usually composed of lines and cubic Bézier curves, but can also be constructed from the outlines of text. Unlike PostScript, PDF does not allow a single path to mix text outlines with lines and curves. Paths can be stroked, filled, fill then stroked, or used for clipping. Strokes and fills can use any color set in the graphics state, including patterns. PDF supports several types of patterns. The simplest is the tiling pattern in which a piece of artwork is specified to be drawn repeatedly. This may be a colored tiling pattern, with the colors specified in the pattern object, or an uncolored tiling pattern, which defers color specification to the time the pattern is drawn. Beginning with PDF 1.3 there is also a shading pattern, which draws continuously varying colors. There are seven types of shading patterns of which the simplest are the axial shading (Type 2) and radial shading (Type 3). Raster images Raster images in PDF (called Image XObjects) are represented by dictionaries with an associated stream. The dictionary describes the properties of the image, and the stream contains the image data. (Less commonly, small raster images may be embedded directly in a page description as an inline image.) Images are typically filtered for compression purposes. Image filters supported in PDF include the following general-purpose filters: ASCII85Decode, a filter used to put the stream into 7-bit ASCII, ASCIIHexDecode, similar to ASCII85Decode but

less compact, FlateDecode, a commonly used filter based on the deflate algorithm defined in RFC 1951 (deflate is also used in the gzip, PNG, and zip file formats among others); introduced in PDF 1.2; it can use one of two groups of predictor functions for more compact zlib/deflate compression: Predictor 2 from the TIFF 6.0 specification and predictors (filters) from the PNG specification (RFC 2083), LZWDecode, a filter based on LZW Compression; it can use one of two groups of predictor functions for more compact LZW compression: Predictor 2 from the TIFF 6.0 specification and predictors (filters) from the PNG specification, RunLengthDecode, a simple compression method for streams with repetitive data using the run-length encoding algorithm and the image-specific filters, DCTDecode, a lossy filter based on the JPEG standard, CCITTFaxDecode, a lossless bi-level (black/white) filter based on the Group 3 or Group 4 CCITT (ITU-T) fax compression standard defined in ITU-T T.4 and T.6, JBIG2Decode, a lossy or lossless bi-level (black/white) filter based on the JBIG2 standard, introduced in PDF 1.4, and JPXDecode, a lossy or lossless filter based on the JPEG 2000 standard, introduced in PDF 1.5. Normally all image content in a PDF is embedded in the file. But PDF allows image data to be stored in external files by the use of external streams or Alternate Images. Standardized subsets of PDF, including PDF/A and PDF/X, prohibit these features. Text Text in PDF is represented by text elements in page content streams. A text element specifies that characters should be drawn at certain positions. The characters are specified using the encoding of a selected font resource. A font object in PDF is a description of a digital typeface. It may either describe the characteristics of a typeface, or it may include an embedded font file. The latter case is called an embedded font while the former is called an unembedded font. The font files that may be embedded are based on widely used standard digital font formats: Type 1 (and its compressed variant CFF), TrueType, and (beginning with PDF 1.6) OpenType. Additionally PDF supports the Type 3 variant in which the components of the font are described by PDF graphic operators. Fourteen typefaces, known as the standard 14 fonts, have a special significance in PDF documents: Times (v3) (in regular, italic, bold, and bold italic) Courier (in regular, oblique, bold and bold oblique) Helvetica (v3) (in regular, oblique, bold and bold oblique) Symbol Zapf Dingbats These fonts are sometimes called the base fourteen fonts. These fonts, or suitable substitute fonts with the same metrics, should be available in most PDF readers, but they are not guaranteed to be

available in the reader, and may only display correctly if the system has them installed. Fonts may be substituted if they are not embedded in a PDF. Within text strings, characters are shown using character codes (integers) that map to glyphs in the current font using an encoding. There are several predefined encodings, including WinAnsi, MacRoman, and many encodings for East Asian languages and a font can have its own built-in encoding. (Although the WinAnsi and MacRoman encodings are derived from the historical properties of the Windows and Macintosh operating systems, fonts using these encodings work equally well on any platform.) PDF can specify a predefined encoding to use, the font's built-in encoding or provide a lookup table of differences to a predefined or built-in encoding (not recommended with TrueType fonts). The encoding mechanisms in PDF were designed for Type 1 fonts, and the rules for applying them to TrueType fonts are complex. For large fonts or fonts with non-standard glyphs, the special encodings Identity-H (for horizontal writing) and Identity-V (for vertical) are used. With such fonts, it is necessary to provide a ToUnicode table if semantic information about the characters is to be preserved. Transparency The original imaging model of PDF was, like PostScript's, opaque: each object drawn on the page completely replaced anything previously marked in the same location. In PDF 1.4 the imaging model was extended to allow transparency. When transparency is used, new objects interact with previously marked objects to produce blending effects. The addition of transparency to PDF was done by means of new extensions that were designed to be ignored in products written to PDF 1.3 and earlier specifications. As a result, files that use a small amount of transparency might view acceptably by older viewers, but files making extensive use of transparency could be viewed incorrectly by an older viewer. The transparency extensions are based on the key concepts of transparency groups, blending modes, shape, and alpha. The model is closely aligned with the features of Adobe Illustrator version 9. The blend modes were based on those used by Adobe Photoshop at the time. When the PDF 1.4 specification was published, the formulas for calculating blend modes were kept secret by Adobe. They have since been published. The concept of a transparency group in PDF specification is independent of existing notions of "group" or "layer" in applications such as Adobe Illustrator. Those groupings reflect logical relationships among objects that are meaningful when editing those objects, but they are not part of the imaging model. Additional features Logical structure and accessibility A "tagged"

PDF (see clause 14.8 in ISO 32000) includes document structure and semantics information to enable reliable text extraction and accessibility. Technically speaking, tagged PDF is a stylized use of the format that builds on the logical structure framework introduced in PDF 1.3. Tagged PDF defines a set of standard structure types and attributes that allow page content (text, graphics, and images) to be extracted and reused for other purposes. Tagged PDF is not required in situations where a PDF file is intended only for print. Since the feature is optional, and since the rules for Tagged PDF were relatively vague in ISO 32000-1, support for tagged PDF among consuming devices, including assistive technology (AT), is uneven as of 2021. ISO 32000-2, however, includes an improved discussion of tagged PDF which is anticipated to facilitate further adoption. An ISO-standardized subset of PDF specifically targeted at accessibility, PDF/UA, was first published in 2012. Optional Content

ELEMENT BELOW