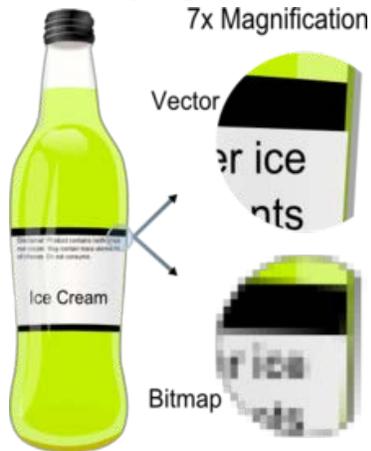


Name: _____

Period: _____

Vector graphics



Example showing effect of vector graphics versus raster graphics. The original vector-based illustration is at the left. The upper-right image illustrates magnification of 7x as a vector image. The lower-right image illustrates the same magnification as a bitmap image. Raster images are based on pixels and thus scale with loss of clarity, while vector-based images can be scaled indefinitely without degrading.

Vector graphics is the use of geometrical [primitives](#) such as [points](#), [lines](#), [curves](#), and shapes or [polygon\(s\)](#), which are all based upon mathematical equations, to represent [images](#) in [computer graphics](#).

Vector graphics formats are complementary to [raster graphics](#), which is the representation of images as an array of [pixels](#), as it is typically used for the representation of photographic images.^[1] There are instances when working with vector tools and formats is best practice, and instances when working with raster tools and formats is best practice. There are times when both formats come together. An understanding of the advantages and limitations of each technology and the relationship between them is most likely to result in efficient and effective use of tools.

Overview

Computer displays are made up from small dots called [pixels](#). The picture is built up from these dots. The smaller and closer the dots are together, the better the quality of the image but the bigger the file needed to store the data. If the image is magnified it becomes grainy as the resolution of the eye enables it to pick out individual pixels. Vector graphics files store the lines, shapes and colours that make up an image as mathematical formulae. A vector graphics program uses the mathematical formulae to construct the screen image by building the best quality image possible, given the screen resolution, from the mathematical data. The mathematical formulae determine where the dots that make up the image should be placed for the best results when displaying the image. Since these formulae can produce an image

Vector Graphics (page 2)

scalable to any size and detail the quality of the image is only determined by the resolution of the display and the file size of vector data generating the image stays the same. Printing the image to paper will usually give a sharper, higher resolution output than printing it to the screen but can use exactly the same vector data file.

A [vector-graphics drawing software](#) is used for creating and editing vector graphics. The image can be changed by editing screen objects which are then saved as modifications to the mathematical formulae. Mathematical operators in the software can be used to stretch, twist, and colour component object in the picture or the whole picture and these tools are presented to the user intuitively through the graphical user interface of the computer. It is possible to save the screen image produced as a bitmap/raster file or generate a [bitmap](#) of any resolution from the vector file for use on any device.

The size of the file generated will depend on the resolution required but the size of the vector file generating the bitmap/raster file will always remain the same. Thus it is easy to convert from a vector file to a range of bitmap/raster [file formats](#) but it is very much more difficult to go in the opposite direction, especially if subsequent editing of the vector picture is required. It might be an advantage to save an image created from a vector source file as a bitmap/raster format because different systems have different and incompatible vector formats and some might not support vector graphics at all. However, once the file is converted from the vector format it is likely to be bigger and it loses the advantages of scalability without losing resolution. Editing will also lose the convenience of being able to work on individual parts of the picture as discrete objects. Vector formats are not always appropriate in graphics work. For example, digital devices such as cameras and scanners produce raster graphics that are impractical to convert into vectors and so for this type of work the editor will operate on the pixels rather than drawing objects defined by mathematical formulae. Comprehensive graphics tools will combine images from vector and raster sources and might provide editing tools for both since some parts of the overall work could be sourced from a camera and others drawn using vector tools in the software.

The [W3C](#) standard for vector graphics is [svg](#). The standard is complex and has been relatively slow to be established at least in part owing to commercial interests. Many web browsers have now some support for rendering svg data but full implementations of the standard are still comparatively rare.



An original reference photograph before [vectorization](#).

Vector Graphics (page 3)



Detail can be added or removed from vector art. Vector illustrations can have their own colours, allowing artists to achieve desired results.

One of the first uses of vector graphic displays was the [US SAGE air defense system](#). Vector graphics systems were only retired from U.S. en route [air traffic control](#) in 1999, and are likely still in use in military and specialised systems. Vector graphics were also used on the [TX-2](#) at the [MIT Lincoln Laboratory](#) by computer graphics pioneer [Ivan Sutherland](#) to run his program [Sketchpad](#) in 1963.

Subsequent vector graphics systems include [Digital's](#) GT40 [1]. There was a home gaming system that used vector graphics called [Vectrex](#) as well as various [arcade games](#) like [Asteroids](#) and [Space Wars](#). Storage scope displays, such as the [Tektronix 4014](#), could also create dynamic vector images by driving the display at a lower intensity.

Modern vector graphics displays can sometimes be found at [laser light shows](#), using two fast-moving X-Y [mirrors](#) to rapidly draw shapes and text on a large screen.

The term vector graphics is mainly used today in the context of two-dimensional computer graphics. It is one of several modes an artist can use to create an image on a raster display. Other modes include text, [multimedia](#) and [3D rendering](#). Virtually all modern 3D rendering is done using extensions of 2D vector graphics techniques. [Plotters](#) used in technical drawing still draw vectors directly to paper.

Motivation

For example, consider [circle](#) of [radius](#) r . The main pieces of [information](#) a [program](#) needs in order to draw this circle are

1. that the following data are describing a circle
2. the radius r and equation of a circle
3. the [location](#) of the center point of the circle
4. stroke line style and colour (possibly transparent)
5. fill style and colour (possibly transparent)

Vector Graphics, Page 4

Advantages to this style of [drawing](#) over [raster graphics](#):

- This minimal amount of information translates to a much smaller [file size](#) compared to large raster images (the [size](#) of representation doesn't depend on the [dimensions](#) of the object), though a vector graphic with a small file size is often said to lack detail compared with a real world photo.
- Correspondingly, one can indefinitely zoom in on e.g. a circle arc, and it remains smooth. On the other hand, a polygon representing a curve will reveal being not really curved.
- On zooming in, lines and curves need not get wider proportionally. Often the width is either not increased or less than proportional. On the other hand, irregular curves represented by simple geometric shapes may be made proportionally wider when zooming in, to keep them looking smooth and not like these geometric shapes.
- The parameters of objects are stored and can be later modified. This means that [moving](#), [scaling](#), [rotating](#), [filling](#) etc. doesn't degrade the [quality](#) of a drawing. Moreover, it is usual to specify the dimensions in [device-independent units](#), which results in the best possible [rasterization](#) on raster [devices](#).
- From a 3-D perspective, rendering shadows is also much more realistic with vector graphics, as shadows can be abstracted into the rays of light which form them. This allows for photo realistic images and renderings.

Typical primitive objects

- lines and [polylines](#)
- [polygons](#)
- [circles](#) and [ellipses](#)
- [Bézier curves](#)
- [Bezignons](#)
- [Text](#) (in computer fonts such as [TrueType](#) where each letter is created from Bézier curves)

This list is not complete. There are various types of curves ([Catmull-Rom splines](#), [NURBS](#) etc.), which are useful in certain applications.

Often, a [bitmap](#) image is considered as a primitive object. From the conceptual view, it behaves as a [rectangle](#).

Vector operations

[Vector graphics editors](#) typically allow rotation, movement, mirroring, stretching, skewing, [affine transformations](#), changing of [z-order](#) and combination of primitives into more complex objects.

More sophisticated [transformations](#) include set [operations](#) on closed [shapes](#) ([union](#), [difference](#), [intersection](#), etc.).

Vector graphics are ideal for simple or composite drawings that need to be device-independent, or do not need to achieve [photo-realism](#). For example, the [PostScript](#) and [PDF page description languages](#) use a vector graphics model.

Advanced vector artists are developing more photo-realistic vector art every day. ^{[[citation needed](#)]}

Vector Graphics, Page 5

Printing

Vector art is key for [printing](#). Since the art is made from a series of mathematical curves it will print very crisp even when resized. For instance one can take the same vector logo and print it on a [business card](#), and then enlarge it to [billboard](#) size and keep the same crisp quality. A low-resolution [raster graphic](#) would blur excessively if it were enlarged from business card size to billboard size.

3D modeling

In [3D computer graphics](#), vectorized surface representations are most common (bitmaps can be used for special purposes such as surface texturing, height-field data and [bump mapping](#)). At the low-end, simple [meshes](#) of [polygons](#) are used to represent geometric detail in applications where interactive [frame rates](#) or [simplicity](#) are important. At the high-end, where one is willing to trade-off higher rendering times for increased image [quality](#) and [precision](#), smooth [surface](#) representations such as [Bézier patches](#), [NURBS](#) or [Subdivision surfaces](#) are used. One can however achieve a smooth surface rendering from a polygonal mesh through the use of shading algorithms such as [Phong](#) and [Gouraud](#).

Formats

One example of vector graphics format is [SVG](#) (Scalable Vector Graphics), an [open standard](#) created and developed by the [World Wide Web Consortium](#) to address the need (and attempts of several corporations) for a versatile, [scriptable](#) and all-purpose vector format for the web and otherwise. Another example is [VML](#), a proposed standard that was adopted by [Microsoft](#).

The [SWF](#) Adobe's (f. Macromedia's) file format, is also a vector-based container to store animation. animation.

Assignment

Name: _____ Period: _____

NOTES ON VECTOR IMAGES

Raster Images are made up of _____.

Instead of pixels, Vector Images store the _____, _____, and _____ that make up an image.

Vector graphics is the use of _____ primitives, which are all based upon _____ equations to represent images.

Vector graphics are _____ scalable than raster images because vector graphics use formulae to create the images instead of pixels.

The size of the vector file _____, regardless of the size of the file generated.

The W3C standard for vector graphics is _____.

Virtually all 3D rendering is done using extensions of _____.

What pieces of information would a vector program need in order to draw a circle?

Some advantages to vector over raster graphics - smaller file size; indefinitely zoom-able and lines remain smooth; on zooming, lines and curves do not have to get wider proportionally; parameters of objects are stored and can be modified; rendering shadows in 3D is more realistic.

What are some of the typical primitive objects used in vector graphics?

Why is vector art key for printing?

What are two shading algorithms used in 3D Modeling?