



# IDX G9 Computer Science S

## Study Guide Semester 1 Finals

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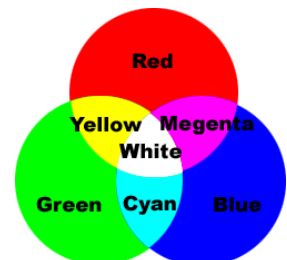
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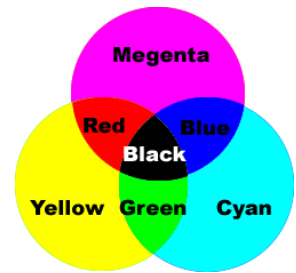
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## 2.1 Computer Colors

- A computer's primary colors are **red, green and blue**
  - all colors we generate form the three spectral hues of red, green and blue

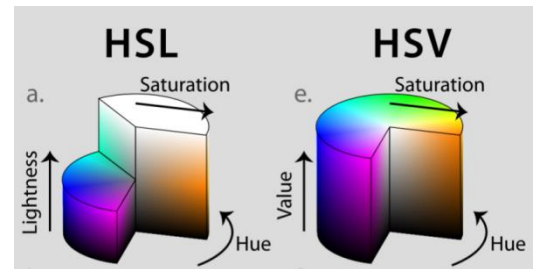


- CMYK: proper reference for printed color
- HSV/HSL/HSI
  - H: Hue -> the pure dominant color (original colorness)
  - S: Saturation -> intensity/purity of a color
  - V: Value -> lightness or darkness
  - L: Lightness -> color's brightness (amount of black/white)
  - I: Intensity -> brightness or dullness of a color



- Binary notation of colors: 24 numbers to represent a color

- EG: 111111 111111 111111 is white
- The first 6 “1”s represent the red part of the color, the next group of “1”s represent the green part and the last group of “1”s represent the blue part



- Hexadecimal: using 6 letters/numbers to represent a color

- EG: #FF FF FF represents white
- The first group of “F”s represent the red part, the second group represents green, and the third group represents blue

- Ways to store characters:

- **Morse code:** the use of dots and dashes. This can be ineffective as letters can be mixed up

- ASC II: developed from telegraph codes, encodes 128 specified characters into **7-bit integers**

- For letters, it is a capital letter, start with “10” and lowercase letters start with “11”

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040	#32	Space	64	40	100	#64	@	96	60	140	#96	`
1	1	001	SOH (start of heading)	33	21	041	#33	!	65	41	101	#65	A	97	61	141	#97	a
2	2	002	STX (start of text)	34	22	042	#34	"	66	42	102	#66	B	98	62	142	#98	b
3	3	003	ETX (end of text)	35	23	043	#35	#	67	43	103	#67	C	99	63	143	#99	c
4	4	004	EOF (end of transmission)	36	24	044	#36	\$	68	44	104	#68	D	100	64	144	#100	d
5	5	005	ENQ (enquiry)	37	25	045	#37	%	69	45	105	#69	E	101	65	145	#101	e
6	6	006	ACK (acknowledge)	38	26	046	#38	&	70	46	106	#70	F	102	66	146	#102	f
7	7	007	BEL (bell)	39	27	047	#39	'	71	47	107	#71	G	103	67	147	#103	g
8	8	010	BS (backspace)	40	28	050	#40	(	72	48	110	#72	H	104	68	150	#104	h
9	9	011	TAB (horizontal tab)	41	29	051	#41	)	73	49	111	#73	I	105	69	151	#105	i
10	A	012	LF (NL line feed, new line)	42	2A	052	#42	*	74	4A	112	#74	J	106	6A	152	#106	j
11	B	013	VT (vertical tab)	43	2B	053	#43	+	75	4B	113	#75	K	107	6B	153	#107	k
12	C	014	FF (NP form feed, new page)	44	2C	054	#44	,	76	4C	114	#76	L	108	6C	154	#108	l
13	D	015	CR (carriage return)	45	2D	055	#45	-	77	4D	115	#77	M	109	6D	155	#109	m
14	E	016	SO (shift out)	46	2E	056	#46	.	78	4E	116	#78	N	110	6E	156	#110	n
15	F	017	SI (shift in)	47	2F	057	#47	/	79	4F	117	#79	O	111	6F	157	#111	o
16	10	020	DLE (data link escape)	48	30	060	#48	0	80	50	120	#80	P	112	70	160	#112	p
17	11	021	DC1 (device control 1)	49	31	061	#49	1	81	51	121	#81	Q	113	71	161	#113	q
18	12	022	DC2 (device control 2)	50	32	062	#50	2	82	52	122	#82	R	114	72	162	#114	r
19	13	023	DC3 (device control 3)	51	33	063	#51	3	83	53	123	#83	S	115	73	163	#115	s
20	14	024	DC4 (device control 4)	52	34	064	#52	4	84	54	124	#84	T	116	74	164	#116	t
21	15	025	NAK (negative acknowledge)	53	35	065	#53	5	85	55	125	#85	U	117	75	165	#117	u
22	16	026	SYN (synchronous idle)	54	36	066	#54	6	86	56	126	#86	V	118	76	166	#118	v
23	17	027	ETB (end of trans. block)	55	37	067	#55	7	87	57	127	#87	W	119	77	167	#119	w
24	18	030	CAN (cancel)	56	38	070	#56	8	88	58	130	#88	X	120	78	170	#120	x
25	19	031	EM (end of medium)	57	39	071	#57	9	89	59	131	#89	Y	121	79	171	#121	y
26	1A	032	SUB (substitute)	58	3A	072	#58	:	90	5A	132	#90	Z	122	7A	172	#122	z
27	1B	033	ESC (escape)	59	3B	073	#59	;	91	5B	133	#91	[	123	7B	173	#123	{
28	1C	034	FS (file separator)	60	3C	074	#60	<	92	5C	134	#92	\	124	7C	174	#124	
29	1D	035	GS (group separator)	61	3D	075	#61	=	93	5D	135	#93	]	125	7D	175	#125	}
30	1E	036	RS (record separator)	62	3E	076	#62	>	94	5E	136	#94	^	126	7E	176	#126	~
31	1F	037	US (unit separator)	63	3F	077	#63	?	95	5F	137	#95	_	127	7F	177	#127	DEL

Source: [www.LookupTables.com](http://www.LookupTables.com)

- Graphic formats can be formatted in:

- GIF, shows 256 kinds of colors at most in one picture

- JPEG: millions of kinds of colors ( $2^8 \times 2^8 \times 2^8 = 16777216$ ), saves memory space in computer
- PNG: combines advantages of GIF and JPEG, good quality, can be transparent, not very popular as many web pages cannot show pictures in this format
- BMP/RLE: one of the most popular formats used to save images on windows operating system
- PSD: used in photoshop, save all detailed elements made in photoshop such as layers, color modes, path and channel etc, occupy large memory in computer but can be compressed
- HEIF: supports multiple bit depths, depending on the encoder and use case, memory is about 50% smaller than the JPEG format, shows billions of colors ( $2^{30}$ ), records images with richer information, compatibility is limited
- bit depth: color depth per channel, not the total file size or container overhead

## 2.2 Digital Graphics

- An image created/edited on a computer is either a bitmapped or vector graphic
  - **Bitmapped:** AKA raster graphics, consists of pixels, if you enlarge a bitmap you enlarge a pixel
    - pixels become more obvious and image loses crispness and clarity
  - **Vector:** uses mathematical formulas to define lines, curves and other attributes of digital images
    - you use vector graphics editing program
    - Vector files are generally much smaller than bitmapped
- The number of **pixel per inch** (ppi) determines the resolution of bitmap graphics
  - photo display on a computer screen usually looks realistic at 72 ppi
  - vector graphics do not rely on resolution for clarity, but its' display on a computer screen does
- **color depth:** in graphic files and applications, color depth refers to the number of distinct colors an image can contain/how many bits per pixel
  - EG 24-bit image has color depth of 16.7 million colors, called **full color image**

- **Field of View/Field of vision (FOV):** extent of observable world that is seen at any given moment
  - Humans have  $\approx 210$  degree of forward facing horizontal arc of their visual field'
  - vertical range of the visual field in humans is around 150 degrees
  - some birds have complete/nearly complete 360 degree FOV
- **Aspect ratio:** relationship between its width and height
  - expressed as (x,y)
  - common aspect ratios: 5:4, 4:3, 16:10, 16:9
- Brief history
  - **2003:** most computer monitors had 4:3 aspect ratio, some had 5:4
  - **2003-2006:** 16:10 became common in laptops and standalone monitors
  - **2008:** industry moved from 4:3 and 16:10 to 19:9 as the standard ratio
  - **2010:** All monitors and laptops moved to 16:9 aspect ratio
  - **2011:** 16:9 reso of 1920\*1080 became popular among steam users
  - **2012:** resolution became 1366\*768

## 2.3 Alpha Channel

- **alpha compositing:** process of combining an image with a background to create the appearance of partial or full transparency
  - keep an associate matte for each element
  - In a 2D image element, which stores a color for each pixel, additional data is stored in the alpha channel with a value between 0 and 1
    - 0 means pixel does not have any coverage info and is transparent
    - 1 means the pixel is opaque because the geometry overlapped the pixel
  - one more number is required to store **alpha**
    - from (148,255,255) to (148,255,255,0)
      - first 3 numbers imply the color
      - last three imply the alpha
- if three primary colors share the same number, this color contains only brightness, it can only be black, white or gray

- (0,0,0) is black
- (255,255,255) is white
- (100,100,100) is gray
- **premultiplied alpha:** if the alpha channel is used in an image, its common to also multiply the color by the alpha value
  - saves space
  - **linear interpolation:** given two red points, the blue line is the linear interpolate between the points, and then value y at x may be found using this method

## 2.4 Computer monitors

- **computer monitors:** the size of a display is usually given by monitor manufacturers based on the diagonal
  - measure in unit inch
  - display devices: cathode ray tube (CRT), liquid crystal display (LCD), organic light-emitting diode (OLED)
    - **CRT:** old fashioned, vacuum tube containing an electron gun and phosphorescent screen used to view images
    - **LCD:** most common, has diffraction grating, crystal and backlight
    - **OLED:** monitor of the future, simple structure, self emissive

## 2.5 Image Compression

- **uncompressed image - raw file:** captured by a digital camera or scanner's sensors, this captures a high level of image detail, with large file sizes and lossless quality
  - direct image data means you start with a high-quality image that can be edited, converted and compressed in a non-destructive manner
- **lossy vs lossless**
  - lossless: preferred for archival purposes, for medical imaging, technical drawings, clip art, comics
  - lossy: suitable for natural images EG photographs in applications
- **lossless compression**

- Run-length encoding (RLE) is a simple form of data compression where runs of data are stored as a single data value and count, rather than as the original run
  - example of RLE: W representing white and B representing black:  
WWWWWBWW
  - instead this can be compressed into 5W1B2W
- Differential pulse-code modulation (DPCM) encodes the changes between consecutive samples of a signal rather than the signal's value directly
  - reduces the bit rate
  - input can be an analog signal or digital signal
  - methods of encoding:
    - quantize the samples, output is the difference between the current and previous sample
    - quantize the difference between the current sample and output of a local decoder
  - color spaced is reduced to the most common colors, these selected colors are defined in a color palette stored within the image header
    - each pixel references the index of its corresponding color in the palette
    - this approach can be combined with dithering to minimize posterization artifacts
- **entropy encoding:**
  - **Huffman coding:** separating the input into component symbols and replacing each with a code, uses variable length codes to represent different characters
    - shorter codes -> assigned to more frequently occurring characters and longer to less frequent ones, results in compressed data representation
    - optimal for minimizing the total number of bits used
  - **Arithmetic coding:** encoding the entire message into a single number, a fraction  $n$  where  $(0 \leq n \leq 1)$
- **chroma subsampling:** human eye perceives spatial changes of brightness more sharply than color, so this method averages/drops some of the chrominance info in the image

- **transform coding:** most commonly used method, Fourier related transform such as the **discrete cosine transform (DCT)** is widely used
  - wavelet transform is also used extensively, followed by quantization and entropy coding

### 3.1 Frame Rate

- **Video: fast switching pictures**
  - Frame rate: AKA frame frequency/frames per second (FPS); the frequency at which an imaging device produces unique consecutive images called frames
  - unit: FPS, Hz(Hertz)
  - threshold of human visual perception: 24 fps
- Standard frame rates in cinema/TV: 24 fps(cinematic films), 25 fps(PAL(Asia), SECAM(Europe)), 30 fps(NTSC, North America).
- 24 fps: progressive format, transferring video signal to film (fps of film: 23.976)
- 48 fps: progressive format trialed in the film industry, reduce motion blur and flicker, EG “The Hobbit”
- 50 or 60 fps: HDTV/video in high definition based on 25 and 30 fps

### 3.2 Data Rate and Bandwidth

- Stream: sequence of data elements made available over time
  - divides a video into several parts, which are transported one by one, while one part is playing the next is being loaded
- Bandwidth: measurement of bit-rate of available or consumed data communication resources expressed in bits per second or multiples of it
- Data rate: speed of stream transmission
  - decides how much data will be transported each second
  - Conversion:
    - 1 TB = 1024 GB
    - 1 GB = 1024 MB
    - 1 MB = 1024 KB (Kilobyte)
    - 1 KB = 1024 Byte

- 1 Byte = 8 bit
- Data rate = File size (bit) / length of file (sec)
- unit of data rate and bandwidth are both bps (bits per second)
- data rate is determined by: screen size, frame rate, and codec
  - data rate of SD vid: around 512 KB-2M
  - data rate of 720P vid: 4MB-16MB
  - data rate of 1080 vid: 8MB-48MB
- Bandwidth of our internet connection should be larger than the data rate of video

### 3.3. 3D Vision

- 3D vision: we see two 2D images separately with our left and right eye, our brain combines them and gives a 3D depth
- **Anaglyph 3D:**
  - stereoscopic 3D effect achieved by means of encoding each eye's image using filters of different colors, typically red and cyan
  - contain two differently filtered colored images, one for each eye
  - color filters to create 3D effect, eg. red-cyan color filters
- **Polarization 3D system:**
  - polarization glasses to create the illusion of 3D images by restricting the light that reaches each eye
  - low-cost eyeglasses which contain a pair of different polarizing filters
  - two images are projected superimposed the same screen or display through different polarizing filters
  - linear polarizer converts an unpolarized beam into one with a single linear polarization:
    - vertical components of all waves are transmitted
    - horizontal components are absorbed and reflected
- **Active Shutter 3D system:**
  - openly presenting the image intended for the left eye while blocking the right eye's view, then presenting the right eye's image while blocking the left eye

- this is repeated rapidly so that the interruptions do not interfere with the perceived fusion of the two images into a single 3D image
- EG NVIDIA 3D vision system
- **HUD:**
  - Head mounted display (HMD): display device worn on the head/part of a helmet, has a small display optic in front of one or each eye
  - EG Google Glasses

### 3.4 Video Compression

- **Uncompressed:** stores every single data of a video, both useful and useless
  - loses no quality during the process of editing or copying from one form of media into another
- **video compression:** encoding or decoding a digital data stream or signal
  - **lossless:** used for archiving data in a compressed form while retaining all the information present in the original stream
  - **lossy:** reduce quality by some amount in order to achieve compression, formats include mpeg, mov, mkv
  - **encoder/decoder:** used in multi-media area for video compression and decompression
  - **codec and format:** old time codec and format are strongly related, even the players are related to the codecs
  - usually format and codec are in pairs, but not always
    - sometimes we cannot open a video with one format while another video with this format can be opened
  - **container format:** special video format that allowed the users to encode videos with different codecs but sharing the same format name or extension
    - eg. AVI, QuickTime(MOV), Mpeg4 etc
    - contain different codecs but allows users to encode audio/vid with different compressors

- Video support:

	MPE 2-4	MPE 2-3	MPE 2-4	H.264	H265	WMV	Real 11.3	Theo	MS MP4	VP8	VP9	MVC
	MP3	WMA	Vorbi s	Opus	AAC	AC-3	DTS	PC M	FLAC	ALAC	DD- HD	DTS- HD
AVI			Not Off	?								?
MP4			Not Off	?	Possi ble							
MXF			?	?								
Ogg												
MOV				?			?					
Web M												
Matr oska												

- Audio support:

### 3.5 Video Connectors

- **Video connectors:** electric connectors for carrying video signal, of either analog or digital format
  - both analog and digital signals are used with some styles of connectors, knowledge of the interface used is necessary for a successful signal transmission
  - some interface types use only a distinctive connectors or family of connectors to ensure compatibility
- **VGA(Video Graphic Array):** three-row 15-pin connector, the 15-pin VGA connector is found on many video cards, computer monitors, and high definition TV sets
  - same VGA cable can be used with a variety of supported VGA resolutions
  - ranging from 640\*350 px at 70 Hz to 1280\*1024 px at 85 Hz and up to 2048\*1536 px at 85 Hz
  - 25 MB/s
- **DVI(Digital Visual Interface):** designed to transmit uncompressed digital video, can be configured to support multiple modes, DVI-D, DVI-A, or DVI-I
  - Digital vid stream: 1920\*1200 at 60 Hz - 2560\*1600 at 60 Hz
  - Analog vid stream: 1920\*1200 at 60 Hz

- 7.92 Gbits/s
- **HDMI:** Proprietary audio/video interface for transferring uncompressed video data and compressed or uncompressed digital audio data
  - 2.25 GB/s
- **Thunderbolt:** 40 Gbits/s

Interface			Connector
Video Only	Analog	Video Graphic Array(VGA)	D-subminiature(15 pins)
	Digital and Analog	Digital Visual Interface(DVI)	DVI connector
Video and Audio	Digital	High-Definition Multimedia Interface(HDMI)	HDMI connector
		Display Port	DisplayPort connector
		Thunderbolt	Mini Display Port (in version 1 and 2) or USB-C(in version 3 and 4)

### 3.6 Storage Devices

- **Magnetic storage:** uses different patterns of magnetisation in a magnetisable material to store data is a form of non-volatile memory
  - Analog recording
  - Digital recording: floppy disk, hard disk

- **Optical storage:** optical disc is a flat, usually circular disc which encodes binary data in the form of pits (0) and lands (1) on a special material (aluminum) on one of its flat surface
  - CD, DVD, HD DVD, Blue-Ray
- **Flash storage:** electron non-volatile computer storage medium that can be electrically erased and reprogrammed
  - memory cards
  - USB flash drives
  - solid0state drives (SSD)