Ph332, Fall 2018 – Study guide for the final exam, Part Two:

(material lectured before the Nov. 1 midterm test, but not used in that test, and the material lectured after the Nov. 1 midterm test.)
The final is "comprehensive", so consider the study guide posted before the midterm test as Part One of the overall guide.

The topics are listed below not exactly in the same order as they were presented in class – but all <u>relevant</u> topics are on the list!

<u>Interference and diffraction of light (Chapter07):</u>

1. "Interference of waves" – what is the meaning of this term?
2. What are the conditions for "constructive interference" and "destructive interference"?
3. What is the result of the interference of two waves of equal frequencies and amplitudes propagating in the opposite directions?
4. What does the "Huygens Principle" state? Be sure that you are able to answer this question using no more than two sentences (and in both there must be a subject and a predicate, remember!)
5. In 1805 Thomas Young performed his famous experiment with light passing through two narrow slits. Based on the Huygens Principle, describe the waves emerging from the double-slit apparatus. What was the important result of the Young's experiments? What did it prove? What pattern did Young observe on the screen, and how did the pattern depend on the spacing between the two slits?
6. A grating is a plate with many parallel slits, with equal spacing between the slits. Consider a grating illuminated by a plane wave from one side, and apply the Huygens Principle describe the waves forming on the other side. Can you explain how "deflected" waves of the "0th order", the "1st order", the "2nd order", etc., are formed?
7. What is the diffraction angle θ for the "first order" deflected wave produced by a grating? The "second order"? The nth order? (*Hint*: $\sin\theta = n\lambda/d$). Suppose that a grating has N = 500 slits per millimeter. The grating is illuminated by a beam of red light from a laser pointer of wavelength λ= 670 nm. Suppose that there is a screen on the other side of the grating. Can you sketch the pattern of "dots" on the screen? Can you calculate the diffraction angle θ for the first-order dot? **Pay attention to the <u>units</u>!** The wavelength is usually given in nanometers (1 nm = 10^{-9} m), the density of the slits (a.k.a. "the grooves") is given as their number N per one millimeter (1 mm = 10^{-3} m) or per one centimeter (1 cm = 10^{-2} m) – and d is not the same as N, but d is **the spacing between the slits**: d = 1mm/N , or d = 1cm/N, respectively. But no matter whether d is expressed in centimeters or in millimeters, it is usually a pretty small number, with two or more zeros after the decimal dot – which is inconvenient; we normally prefer whole numbers, and therefore N is much more often used as a parameter of a grating than d.
8. What effect would you observe if you illuminated a grating with a beam of white light? For which color is the deflection the strongest, and for which is the

smallest? How does it compare with the deflection of light of different colors by a prism?

Polarization of light (Chapter06):

1. Describe the two basic types of wave motion – longitudinal waves, and transverse waves. Which waves can, and which cannot be polarized?
2. Explain the meaning of the term: "a polarized wave".
3. Be sure that you can define polarization, preferably using no more than two sentences (both with a subject and a predicate!) – but it may be a good idea to illustrate your definition by a simple graph.
4. What is the method that can be used for polarizing waves on ropes, but **cannot** be used for light polarization?
5. What defines the polarization direction of a light wave (and of electromagnetic waves, in general?).
6. Describe three methods of obtaining polarized light beams from unpolarized light emitted by sources such as the sun, light bulbs, candle flames, and similar (using "polaroid" filters, "birefringence crystals", or light reflection from the surface of a transparent medium).
7. Explain how the polarizing foil (a.k.a. "polaroid", or "polarizing filter") works. If the intensity of the incident unpolarized light is 100%, what is the max. intensity of the polarized light that passes through such filter? Slightly less than 75%? Than 50%? Than 25%?
8. What is the condition for a beam of light reflected from a surface to be fully polarized? Answ.: the angle between the reflected ray and the refracted ray should be ….. degrees.
9. What is the "Brewster angle"? How can you calculate its value, knowing the refractive index of the reflecting medium, or the refractive indices of the to media, is the light is incident on a plane interface between **two** transparent media? (keep in mind that polarization by reflection does not occur if the light is reflected by a metal, such as, e.g., the light-reflecting layer of silver in a mirror).
10. Explain the meaning of the term "birefringence".
11. Calcite crystals are known to exhibit a very strong birefringence effect. What do you see if you put a calcite crystal on the top of a page with a printed text? If you then put a piece of polarizing foil at the top of the calcite crystal, what would be the effect?
12. Some plastic foils and plastic items put between two polarizers produce spectacular color effects. Can you explain the mechanism of this phenomenon?

Human eye, the mechanism of color vison (daylight) and nighttime vison; the description of colors in terms of numbers it the RGB and HSB schemes (Chapt.08):

1. Human eye: the cone and the rod cells in the retina. What are their roles?

2. Why don't we see colors in low-light conditions?
3. Explain why human eyes exhibit the "red-eyes" effect, and why the eyes of dogs, cats and nocturnal animals show the "eyeshine" effect. Explain how the part of the eye that produces the eyeshine effect improves the animal's low-light vision.
4. There are three types of cone cells in the retina. How do they differ? What light color is each type sensitive to?
5. color". Name the complementary color to each primary color. What do you obtain by adding all three primary colors? What do you obtain by adding two complementary colors? If a color is not a primary color, how can you define a color complementary to it? (*Hint*: a color located opposite to it on the color wheel).
6. Explain what the RGB color scheme is, and the meaning of the three numbers describing a color in this system. What is the range of values these numbers can take? (from 0 to 255, which corresponds to the 0-100% range: 255 has the same meaning as 100%, and a lower number N can be converted to % by multiplying (N/255) by 100% . For instance, in the 0-255 system R = 51 means that the red component in the light color described is (51/255)×100% = 20% of the maximum intensity.
7. The HEX color scheme – essentially, it is the same as the RGB scheme, but the three numbers are expressed not in the decimal notation, but in the **hexadecimal notation.** Numbers up to 255 in hexadecimal notation are singl., e-digit or two-digit; in the former case, we add a zero in front of the digit. Therefore, the HEX code of a color consists of three two-digit numbers, and they are written as a single sequence without space sin betwem. Often the # symbol is written in front of the six-digit sequence. For instance, the #ABD408 color symbol, which means that in this color R = $(AB)_{16}$ = $(171)_{10}$; G = $(D4)_{16}$ = = $(212)_{10}$; and B = $(08)_{16}$ = $(8)_{10}$ is a lime-green (? – please check using one of the "color-pickers", e.g., this one: https://www.rapidtables.com/web/color/RGB_Color.html The conversion from hexadecimal to decimal numbers, and from decimal to hexadecimal numbers can be done "manually", but most often we use tables. Such tables, or on-line converting tools can be readily found in the Web; and if a problem involving hexadecimal color codes is given in the final exam, **appropriate conversion tables will be provided.**
8. Explain what the "RGB Color Wheel" is. **Note:** we **did** discuss in class the property of a color known as the "hue" and how it is defined, based on the color wheel – but only very briefly. You may read about the hue and the hue-based methods of describing colors from the PPT, but in the final exam **there will be no questions about the hue, and hue-based systems of encoding colors, such as, e.g., the "HSB color scheme"**).

<u>Binocular (or three-dimensional) vision (Chapter09):</u>

1. Explain the meaning of the word "parallax". Be able to define parallax using no more than two sentences (both with subject and a predicate, of course!)
2. What is the crucial role of the parallax effect in our two-eye vision?

3. What is the other factor that plays a lesser role in our 3D vision, but still provides a sufficient "depth perception" in many situations when viewing the scene with only one eye?
4. How can we "trick" our brain to get the impression that we look at a real 3D scene, while in fact we look only at photographic pictures? What is the design of a special camera that has to be used to take such pictures? And how such pictures should be viewed afterwards?
5. A stereoscope enables one to get the impression of a real 3D vision by "redirecting" the rays so that each eye looks at a different picture. However, one pair of pictures can be then viewed only by one person. But there are situations when we want the same 3D picture to be watched by many people – e.g., in a 3D movie theater, or when watching a 3D TV program at home. Can you explain the details of some techniques that can be used in such situations?

   (a) The anaglyph method in which the viewers wear red-cyan (or magenta-green) glasses – how are the pictures taken, and how are they projected on the screen? (in Slide 6 in the Power Point presentation of Nov. 25 there is a schematic picture in which there are two separate projectors – but it is really necessary, is it possible to use only a single projector to get the same visual effect? Why are the red-cyan od magneta-green combination of filters used? What is the relation between the two colors in these pairs of filters? (consider, what are the colors of the light that one filter transmits and what colors does it block – and answer the same questions for the other filter). There is a third combination of filters for anaglyph 3D pictures – one filter is yellow – think, what is the color of the other filter? (this combination is seldom used, though).

   (b) The method in which the viewers wear glasses with polarization filters – again, how the images should be projected on the screen?

   (c) The technique utilizing glasses with "active optical filters" that can open or close, and are synchronized with the images appearing on the screen.

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	00	32	20	64	40	96	60	128	80	160	A0	192	C0	224	E0
1	01	33	21	65	41	97	61	129	81	161	A1	193	C1	225	E1
2	02	34	22	66	42	98	62	130	82	162	A2	194	C2	226	E2
3	03	35	23	67	43	99	63	131	83	163	A3	195	C3	227	E3
4	04	36	24	68	44	100	64	132	84	164	A4	196	C4	228	E4
5	05	37	25	69	45	101	65	133	85	165	A5	197	C5	229	E5
6	06	38	26	70	46	102	66	134	86	166	A6	198	C6	230	E6
7	07	39	27	71	47	103	67	135	87	167	A7	199	C7	231	E7
8	08	40	28	72	48	104	68	136	88	168	A8	200	C8	232	E8
9	09	41	29	73	49	105	69	137	89	169	A9	201	C9	233	E9
10	0A	42	2A	74	4A	106	6A	138	8A	170	AA	202	CA	234	EA
11	0B	43	2B	75	4B	107	6B	139	8B	171	AB	203	CB	235	EB
12	0C	44	2C	76	4C	108	6C	140	8C	172	AC	204	CC	236	EC
13	0D	45	2D	77	4D	109	6D	141	8D	173	AD	205	CD	237	ED
14	0E	46	2E	78	4E	110	6E	142	8E	174	AE	206	CE	238	EE
15	0F	47	2F	79	4F	111	6F	143	8F	175	AF	207	CF	239	EF
16	10	48	30	80	50	112	70	144	90	176	B0	208	D0	240	F0
17	11	49	31	81	51	113	71	145	91	177	B1	209	D1	241	F1
18	12	50	32	82	52	114	72	146	92	178	B2	210	D2	242	F2
19	13	51	33	83	53	115	73	147	93	179	B3	211	D3	243	F3
20	14	52	34	84	54	116	74	148	94	180	B4	212	D4	244	F4
21	15	53	35	85	55	117	75	149	95	181	B5	213	D5	245	F5
22	16	54	36	86	56	118	76	150	96	182	B6	214	D6	246	F6
23	17	55	37	87	57	119	77	151	97	183	B7	215	D7	247	F7
24	18	56	38	88	58	120	78	152	98	184	B8	216	D8	248	F8
25	19	57	39	89	59	121	79	153	99	185	B9	217	D9	249	F9
26	1A	58	3A	90	5A	122	7A	154	9A	186	BA	218	DA	250	FA
27	1B	59	3B	91	5B	123	7B	155	9B	187	BB	219	DB	251	FB
28	1C	60	3C	92	5C	124	7C	156	9C	188	BC	220	DC	252	FC
29	1D	61	3D	93	5D	125	7D	157	9D	188	BD	221	DD	253	FD
30	1E	62	3E	94	5E	126	7E	158	9E	190	BE	222	DE	254	FE
31	1F	63	3F	95	5F	127	7F	159	9F	191	BF	223	DF	255	FF