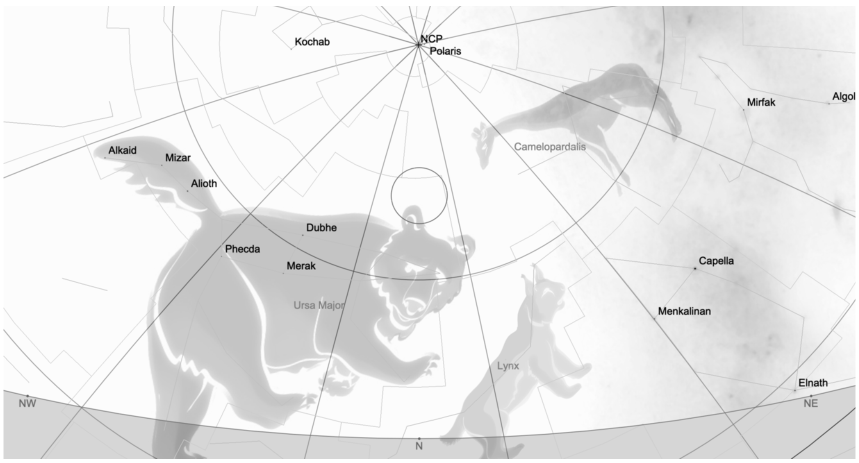
Ancient Astronomy Midterm

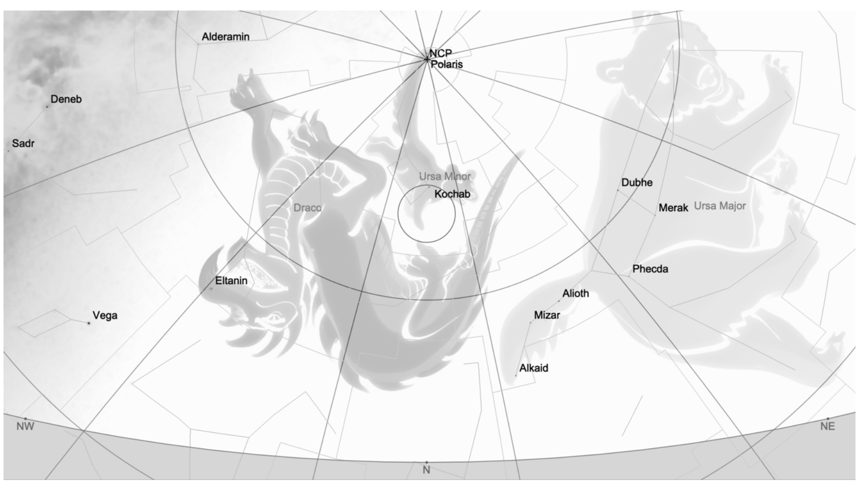
Monday, Oct. 9, 2023 — Covering Evans through Chapter 4

1. The nightly motion of the stars (3 pts)

At 8pm last night if you went outside and looked north, the stars (and constellations) looked like this:



Later if you went outside and looked again, it might look like this:



The goal of this problem is to figure out what the later time is. Note: The times in this problem are in modern hours, not seasonal hours.

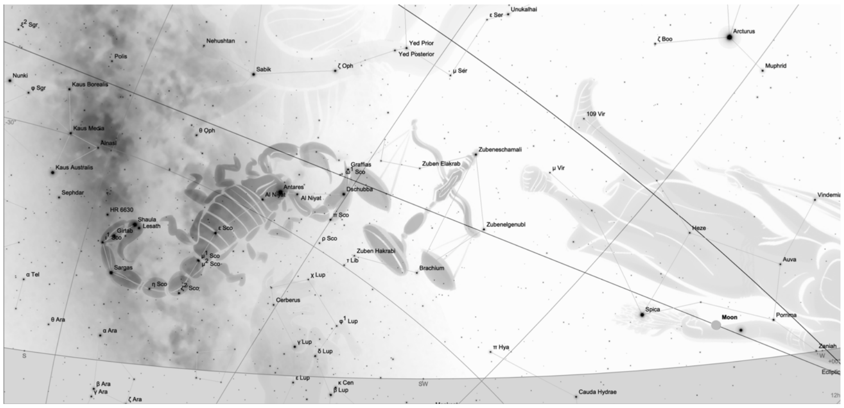
(a) First notice how many degrees apart the RADIAL lines are (the ones emanating from the NCP).

(b) Convert your answer to (a) to hours.

(c) Pick any star. I like Phecda. How many hours has it moved? Add this to 8pm to get the later time.

2. The annual motion of the Sun along the Ecliptic (2pts + 2pts EC)

Below is the chart that you used to plot the motion of the Moon. The chart shows about 85° of the Ecliptic and the chart was correct for 7:30pm on Sat. Sept. 16.



If the Sun began on the Ecliptic in the lower right of this chart, and the chart shows 85° of the Ecliptic, describe where on this chart would the Sun be 85 days later? You can be approximate.

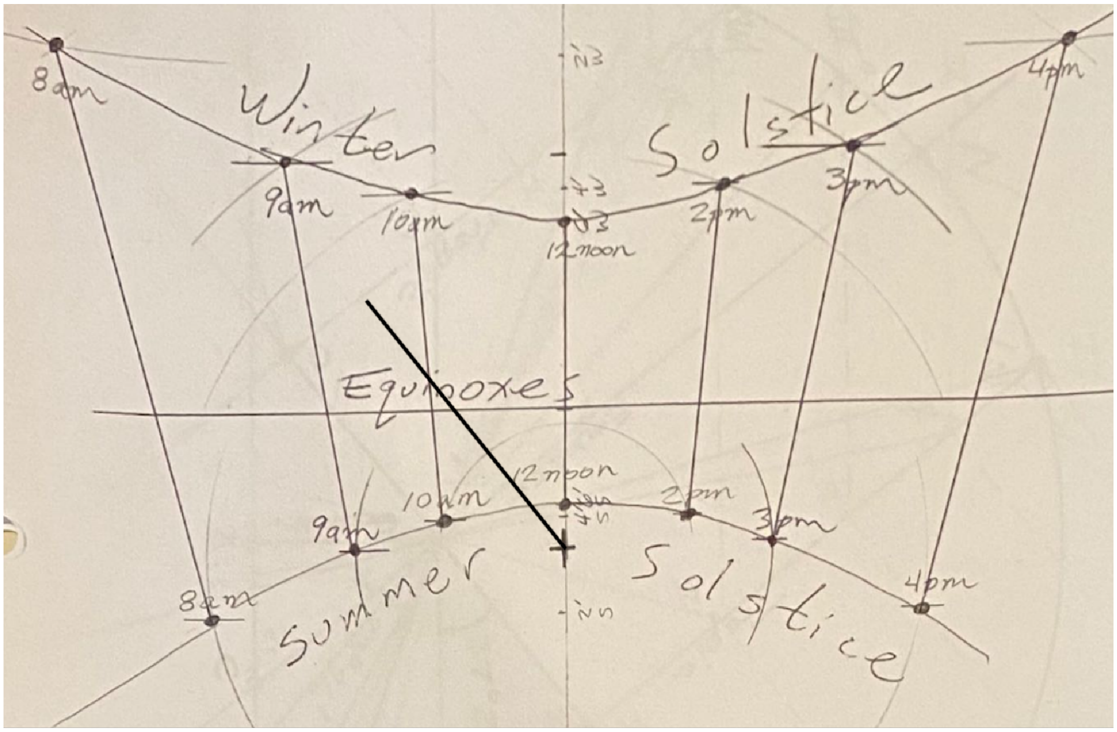
EXTRA CREDIT: To get the extra credit I want you to be accurate to the nearest degree. Still assuming the chart shows 85° of the Ecliptic and the Sun began in the lower right, describe where the Sun would be 85 days later, and where it would be 86 days later?

3. The Tropic of Cancer, Tropic of Capricorn, North Celestial Pole, South Celestial Pole, Celestial Equator (2 pts)

(a) On the Vernal Equinox, which of the Tropic of Cancer, the Tropic of Capricorn, the North Celestial Pole, the South Celestial Pole, or the Celestial Equator is the Sun on (or directly over)?

(b) On the Summer Solstice in the Northern Hemisphere, which of the Tropic of Cancer, the Tropic of Capricorn, the North Celestial Pole, the South Celestial Pole, or the Celestial Equator is the Sun on (or directly over)?

4. Interpret a sundial reading (4 pts)



Above is the sundial I constructed following the procedure in Evans. *It is marked in seasonal hours.* I added a shadow to it with a dark line.

(a) About what time is it? (Note: Use seasonal hours that you can just read off of the sundial — I am not asking you to convert to 21st century hours — this whole problem meant to be easy, so please don't overthink it.)

(b) The Fall Equinox occurs about Sept. 22 or 23. Make a guess as to when this shadows could have occurred. (Note: Yes, there are two guesses, but wait until part (c) for your second guess.)

(c) The Spring Equinox occurs on March 20 or 21. What is a second possible guess as to what date the gnomon's shadow could have fallen as shown?

(d) On the same day as the shadow was seen as above, draw the shadow at 4pm (seasonal hour) on that day. (Note: Be realistic, not sloppy. I want you to show what is happening to the north-south position and the length of the shadow, and if you are too sloppy it won't be clear that you are showing that.)

5. The relationship between zenith angle, latitude, and declination (including when a star is north of you) (3 pts)

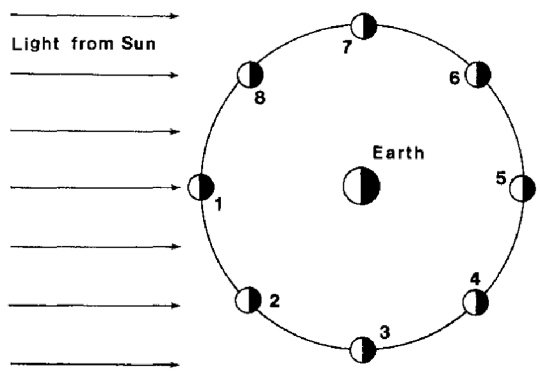
Imagine you watch a star cross the meridian while standing on the Earth's equator. Imagine you observe this crossing to have a zenith angle Z that is 10° south of the zenith.

(a) What is the star's declination, usually written as δ ?

(b) You travel north to the Tropic of Cancer and observe this same star. Now what would its zenith angle Z be when it crosses the meridian?

(c) You travel south to the Tropic of Capricorn and observe this same star. Now what would its zenith angle be when it crosses the meridian? Note: If you are about to report a negative value of Z please use another, better, way of reporting your answer that doesn't involve a negative number!

6. The phases of the Moon (3 pts)



(a) Name the eight phases.

1.
2.
3.
4.
5.
6.
7.
8.

Note: Two of the phases have standard names that are more specific and widely-used than "half full." Use the standard, specific names, not "half full" for those phases.

6. The phases of the Moon (CONT'D)

(b) When you began observing the Moon on Sept. 16, which of the phases 1-8 was it closest to?

(c) When you quit observing on Sept. 22, which of the phases 1-8 was it closest to?

7. An Eratosthenes-style calculation (3 pts)

It is 400km straight south from Deep Springs to Anaheim. Since it is straight south, local noon occurs at the same time in both places. You call up a friend in Anaheim at local noon on the Summer Solstice and compare notes on the angle of the Sun.

You say the Zenith angle is 13.9° south of the Zenith. On your phone call, they tell you the Sun is 10.3° south of the Zenith. Again, you know the distance: they are straight south of you 400km.

From these numbers, calculate the circumference of the Earth. (Note: Not the radius. I asked for the circumference because it is easier.)

Begin by drawing a diagram of the situation. A good diagram will make it obvious what algebra to do.

XXX. An Aristarchus-style calculation

This exam is pretty long. I am going to save an Aristarchus-style calculation for the final.

Table of Ascensions — Needed for Problem 8

TABLE 2.4. Table of Ascensions

Signs	Tens	Right Sphere 12 hours, Lat. 0°		Parallel through Guatemala 13 hours, lat. 16°46′		Parallel through Mobile, Ala. 14 hours, lat. 30°51′	
		Time	Total Time	Time	Total Time	Time	Total Time
Ram	10	9°11′	9°11′	8°00′	8°00′	6°49′	6°49′
	20	9°17′	18°28′	8°06′	16°06′	6°57′	13°46′
	30	9°27′	27°55′	8°19′	24°25′	7°11′	20°57′
Bull	10	9°41′	37°36′	8°37′	33°02′	7°33′	28°30′
	20	9°57′	47°33′	9°00′	42°02′	8°03′	36°33′
	30	10°16′	57°49′	9°27′	51°29′	8°37′	45°10′
Twins	10	10°33′	68°22′	9°55′	61°24′	9°16′	54°26′
	20	10°45′	79°07′	10°21′	71°45′	9°58′	64°24′
	30	10°53′	90°00′	10°45′	82°30′	10°36′	75°00′
Crab	10	10°53′	100°53′	11°01′	93°31′	11°09′	86°09′
	20	10°45′	111°38′	11°09′	104°40′	11°34′	97°43′
	30	10°33′	122°11′	11°10′	115°50′	11°49′	109°32′
Lion	10	10°16′	132°27′	11°05′	126°55′	11°54′	121°26′
	20	9°57′	142°24′	10°55′	137°50′	11°53′	133°19′
	30	9°41	152°05′	10°45′	148°35′	11°49′	145°08′
Virgin	10	9°27′	161°32′	10°35′	159°10′	11°42′	156°50′
	20	9°17′	170°49′	10°27′	169°37′	11°36′	168°26′
	30	9°11′	180°00′	10°23′	180°00′	11°34′	180°00′
Scales	10	9°11′	189°11′	10°23′	190°23′	11°34′	191°34′
	20	9°17′	198°28′	10°27′	200°50′	11°36′	203°10′
	30	9°27′	207°55′	10°35′	211°25′	11°42′	214°52′
Scorpion	10	9°41′	217°36′	10°45′	222°10′	11°49′	226°41′
	20	9°57′	227°33′	10°55′	233°05′	11°53′	238°34′
	30	10°16′	237°49′	11°05′	244°10′	11°54′	250°28′
Archer	10	10°33′	248°22′	11°10′	255°20′	11°49′	262°17′
	20	10°45′	259°07′	11°09′	266°29′	11°34′	273°51′
	30	10°53′	270°00′	11°01′	277°30′	11°09′	285°00′
Goat	10	10°53′	280°53′	10°45′	288°15′	10°36′	295°36′
	20	10°45′	291°38′	10°21′	298°36′	9°58′	305°34′
	30	10°33′	302°11′	9°55′	308°31′	9°16′	314°50′
Water-Pourer	10	10°16′	312°27′	9°27′	317°58′	8°37′	323°27′
	20	9°57′	322°24′	9°00′	326°58′	8°03′	331°30′
	30	9°41′	332°05′	8°37′	335°35′	7°33′	339°03′
Fishes	10	9°27′	341°32′	8°19′	343°54′	7°11′	346°14′
	20	9°17′	350°49′	8°06′	352°00′	6°57′	353°11′
	30	9°11′	360°00′	8°00′	360°00′	6°49′	360°00′

8. Application of Tables of Ascensions (4 pts)

The latitude of Alexandria and the latitude of Mobile, Alabama are both about 31°. For this problem, use the Mobile, Alabama column.

(a) It is sunrise in Alexandria and the Sun is in Twins 30. Find the time in degrees.

(b) What entry (The Sign and the Tens) should you use to find the time of sunset?

(c) What is the degree time that you get using (b)?

(d) What is the difference (c) - (a)?

(e) Convert what you got in (d) to hours.

(f) Is this the length of the day or the night?

(g) Given your answer to (e) and (f), how many equinoctial hours corresponds to 12 seasonal night hours?

Julian–Gregorian Conversions — Needed for Problem 9

TABLE 4.1. Equivalent Dates in the Julian and Gregorian Calendars

	Time Interval	Difference
From	−500 Mar 6 Julian (= Mar 1 Gregorian)	−5 days
Through	−300 Mar 4 Julian (= Feb 28 Gregorian)	
From	−300 Mar 5 Julian (= Mar 1 Gregorian)	−4 days
Through	−200 Mar 3 Julian (= Feb 28 Gregorian)	
From	−200 Mar 4 Julian (= Mar 1 Gregorian)	−3 days
Through	−100 Mar 2 Julian (= Feb 28 Gregorian)	
From	−100 Mar 3 Julian (= Mar 1 Gregorian)	−2 days
Through	100 Mar 1 Julian (= Feb 28 Gregorian)	
From	100 Mar 2 Julian (= Mar 1 Gregorian)	−1 day
Through	200 Feb 29 Julian (= Feb 28 Gregorian)	
From	200 Mar 1 Julian (= Mar 1 Gregorian)	+0 days
Through	300 Feb 28 Julian (= Feb 28 Gregorian)	
From	300 Feb 29 Julian (= Mar 1 Gregorian)	+1 day
Through	500 Feb 28 Julian (= Mar 1 Gregorian)	
From	500 Feb 29 Julian (= Mar 2 Gregorian)	+2 days
Through	600 Feb 28 Julian (= Mar 2 Gregorian)	
From	600 Feb 29 Julian (= Mar 3 Gregorian)	+3 days
Through	700 Feb 28 Julian (=Mar 3 Gregorian)	
From	700 Feb 29 Julian (= Mar 4 Gregorian)	+4 days
Through	900 Feb 28 Julian (= Mar 4 Gregorian)	
From	900 Feb 29 Julian (= Mar 5 Gregorian)	+5 days
Through	1000 Feb 28 Julian (= Mar 5 Gregorian)	
From	1000 Feb 29 Julian (= Mar 6 Gregorian)	+6 days
Through	1100 Feb 28 Julian (= Mar 6 Gregorian)	
From	1100 Feb 29 Julian (= Mar 7 Gregorian)	+7 days
Through	1300 Feb 28 Julian (= Mar 7 Gregorian)	
From	1300 Feb 29 Julian (= Mar 8 Gregorian)	+8 days
Through	1400 Feb 28 Julian (= Mar 8 Gregorian)	
From	1400 Feb 29 Julian (= Mar 9 Gregorian)	+9 days
Through	1500 Feb 28 Julian (= Mar 9 Gregorian)	
From	1500 Feb 29 Julian (=Mar 10 Gregorian)	+10 days
Through	1700 Feb 28 Julian (= Mar 10 Gregorian)	
From	1700 Feb 29 Julian (= Mar 11 Gregorian)	+11 days
Through	1800 Feb 28 Julian (= Mar 11 Gregorian)	
From	1800 Feb 29 Julian (= Mar 12 Gregorian)	+12 days
Through	1900 Feb 28 Julian (= Mar 12 Gregorian)	
From	1900 Feb 29 Julian (= Mar 13 Gregorian)	+13 days
Through	2100 Feb 28 Julian (= Mar 13 Gregorian)	

9. Calendrical conversions and the fall of Rome (4 pts)

Rome's fall had many phases. Some people date the fall of Rome to the execution of the Roman general Orestes, on August 28th, 476. He had put his son, Romulus Augustulus on the throne. Orestes was executed by Odoacer, an invading East German.

(a) Is 476 a leap year?

(b) Using the table on the previous page, and assuming the widely quoted August 28th, 476 date is a Gregorian date, what is the corresponding date on the Julian Calendar?

(c) Now for the hard part. Using the three tables on the following page, compute the Julian Day Number of the date you got in (b). If you want partial credit for a wrong answer, show your reasoning neatly, so I can see if/where you went wrong.

Julian Calendar					
A.D. 0	172 1057	A.D. 600	194 0207	A.D. 1200	215 9357
100	117 7582	700	197 6732	1300	219 5882
200	179 4107	800	201 3257	1400	223 2407
300	183 0632	900	204 9782	1500	226 8932
400	186 7157	1000	208 6307	1600	230 5457
500	190 3682	1100	212 2832	1700	234 1982

TABLE 4.3. Julian Day Number: Years of the Century. Days Elapsed at Greenwich Mean Noon of January 0

0§	0	20*	7 305	40*	14 610	60*	21 915	80*	29 220
1	366	21	7 671	41	14 976	61	22 281	81	29 586
2	731	22	8 036	42	15 341	62	22 646	82	29 951
3	1 096	23	8 401	43	15 706	63	23 011	83	30 316
4*	1 461	24*	8 766	44*	16 071	64*	23 376	84*	30 681
5	1 827	25	9 132	45	16 437	65	23 742	85	31 047
6	2 192	26	9 497	46	16 802	66	24 107	86	31 412
7	2 557	27	9 862	47	17 167	67	24 472	87	31 777
8*	2 922	28*	10 227	48*	17 532	68*	24 837	88*	32 142
9	3 288	29	10 593	49	17 898	69	25 203	89	32 508
10	3 653	30	10 958	50	18 263	70	25 568	90	32 873
11	4 018	31	11 323	51	18 628	71	25 933	91	33 238
12*	4 383	32*	11 688	52*	18 993	72*	26 298	92*	33 603
13	4 749	33	12 054	53	19 359	73	26 664	93	33 969
14	5 114	34	12 419	54	19 724	74	27 029	94	34 334
15	5 479	35	12 784	55	20 089	75	27 394	95	34 699
16*	5 844	36*	13 149	56*	20 454	76*	27 759	96*	35 064
17	6 210	37	13 515	57	20 820	77	28 125	97	35 430
18	6 575	38	13 880	58	21 185	78	28 490	98	35 795
19	6 940	39	14 245	59	21 550	79	28 855	99	36 160

TABLE 4.4. Julian Day Number: Days of the Year

Day of Mo.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	285	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29	*	88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

*In leap years, after February 28, add 1 to the tabulated value.

10. Star Phases (2pts + 2pts EC)

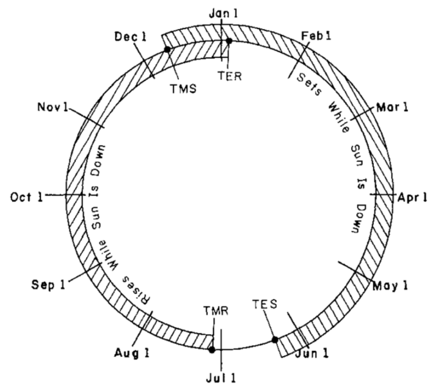
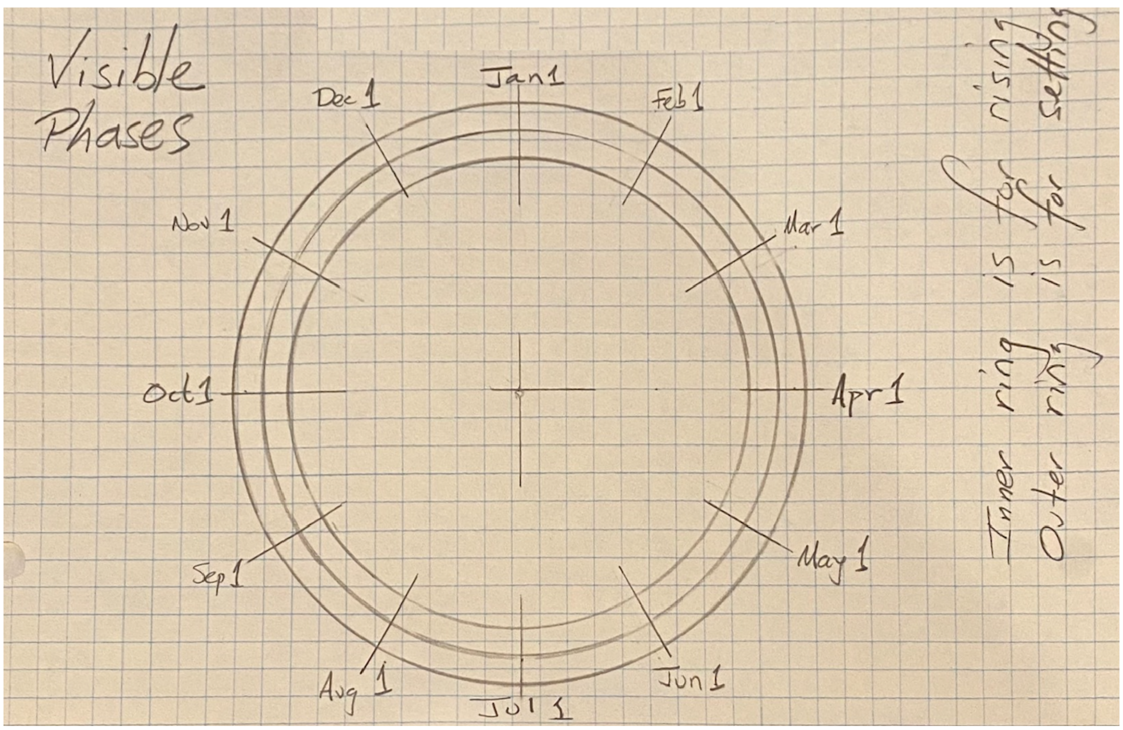


FIGURE 4.6. True phases of Betelgeuse at 40° N latitude. TMR = true morning rising; TMS = true morning setting; TER = true evening rising; TES = true evening setting.

Our book gave the above figure for the true phases of Betelgeuse. Use the inner ring on the chart below to draw the “Rising is Visible” chart for Betelgeuse:



EXTRA CREDIT: Use the outer ring to mark the “Setting is Visible” parts of the chart. To get the extra credit point, have VMR, VER, VMS, and VES clearly marked.

Name ____________________

1. / 3
2. / 2 (+2)
3. / 2
4. / 4
5. / 3
6. / 3
7. / 3
8. / 4
9. / 4
10. / 2 (+2)

GRAND TOTAL

/ 30 MAX