

**EARTH SCIENCE**  
**Tracking the Sun**  
**25 Points**

Overall Score: <input type="text"/>	Overall Grade: <input type="text"/>
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Name \_\_\_\_\_  
 Group \_\_\_\_\_  
 Date \_\_\_\_\_

**PART A**

Examine the attached data table of observed angular altitudes for the Sun on June 21, 2010, September 22, 2010, December 21, 2010, and March 20, 2011. There are several observation times listed for the changing altitude of the Sun on each day. The times are written as military time (e.g. 00:00 is 12:00AM, 12:00 is 12:00PM, 13:00 is 1:00PM, 23:00 is 11:00PM, etc.). The altitude of the Sun was measured every hour at four different latitudes, 0° (the equator), 42.5°S (Lepa, Argentina), 42.5°N (Stoneham), and 90°N (the North Pole). Make a separate graph for each day that shows *the time versus the altitude of the sun* for each of the four locations and then answer the questions in Part B. After plotting the points on your graph for each location, you should connect the dots with a smooth, curving line and the lines for each location should be different, distinct colors.

**PART B**

After constructing your graphs, answer the following questions.

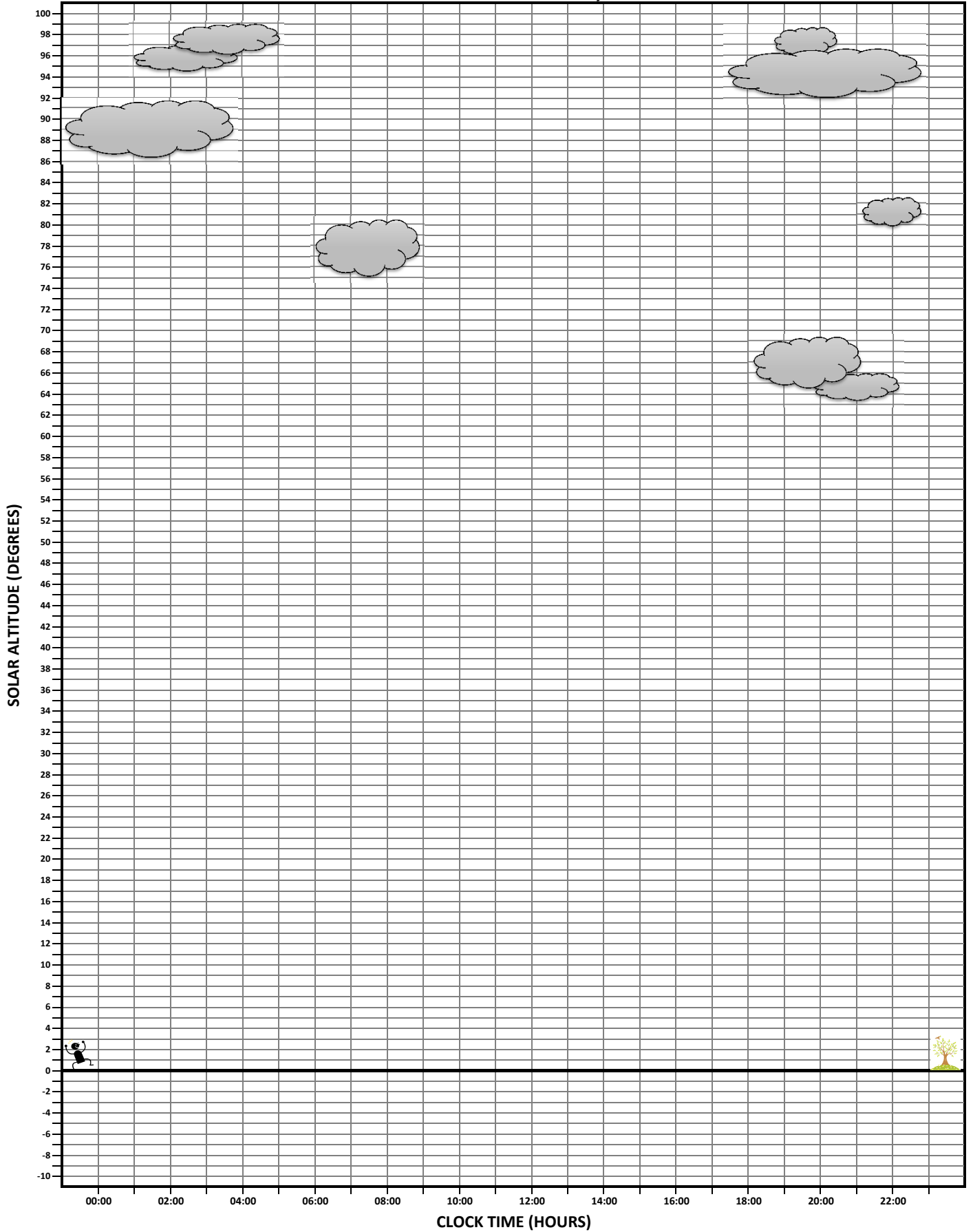
1. What is the longitude for each of the four locations?
2. How would your graphs look if each of the locations was moved to different longitude? For example, how would Stoneham's graphs look if the location was moved to the opposite side of the planet (71.1°E instead of 71.1°W), but the latitude remained the same?
3. Complete the following table by estimating the sunrise, local noon, and sunset times for each location on each of the days. Sunrise and sunset times are determined by the time that your graphed lines cross the horizon. Solar noontime is determined by the peak of your graphed lines.

Date	Stoneham			The Equator			Lepá, Argentina			The North Pole		
	Sunrise	Noon	Sunset	Sunrise	Noon	Sunset	Sunrise	Noon	Sunset	Sunrise	Noon	Sunset
6/21/10												
9/22/10												
12/21/10												
3/20/11												

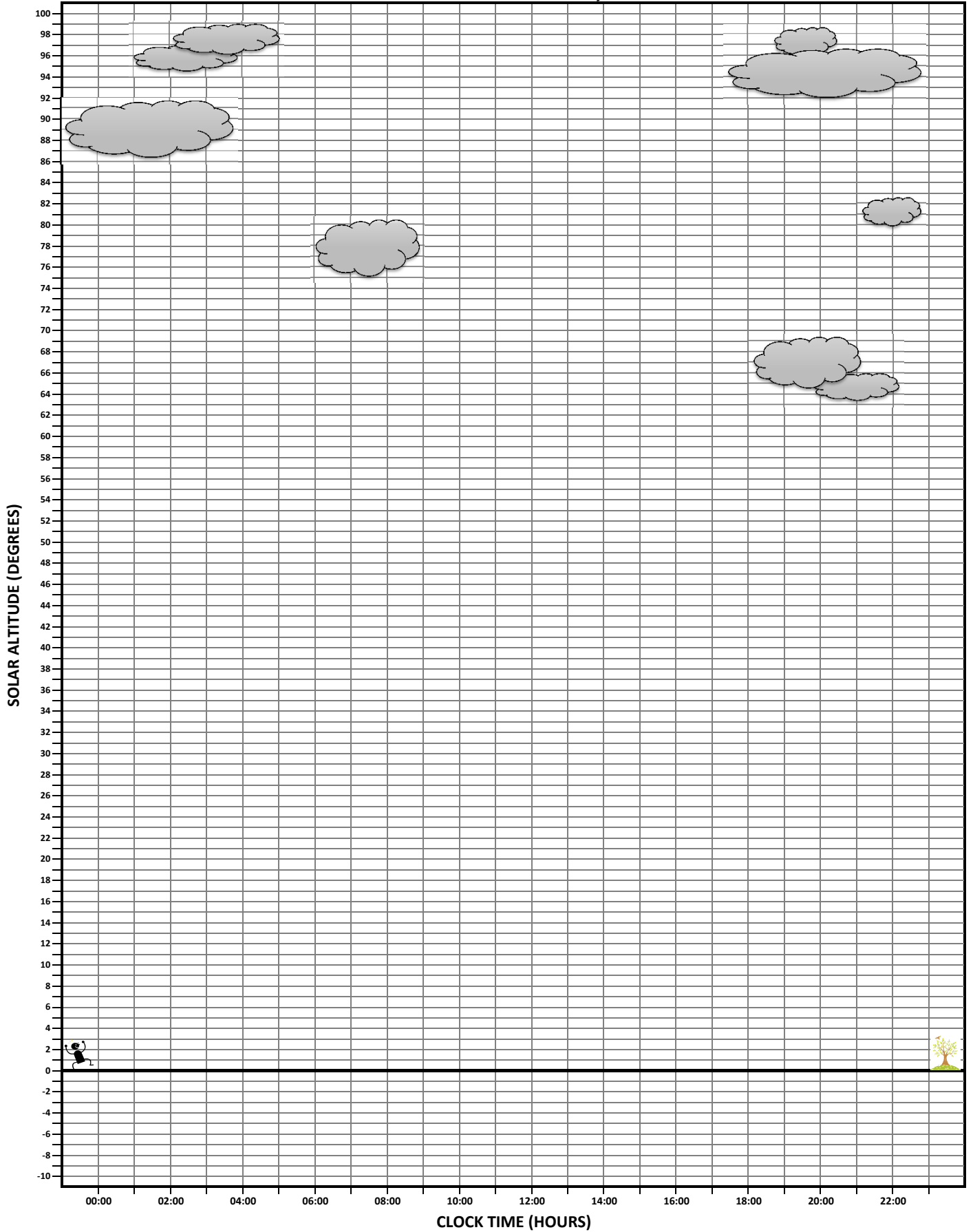
4. Where and when is altitude of the Sun directly overhead (i.e. about 90°)?
5. Compare the Sunrise, Solar Noon, and Sunset times for Stoneham. Describe any trends that you notice for the times and the lengths of days.

6. Compare the Sunrise, Solar Noon, and Sunset times for the Equator. Describe any trends that you notice for the times and the lengths of days.
  
7. Compare the Sunrise, Solar Noon, and Sunset times for Lepá. Describe any trends that you notice for the times and the lengths of days.
  
8. Compare the Sunrise, Solar Noon, and Sunset times for the North Pole. Describe any trends that you notice for the times and the lengths of days.
  
9. Which location has the lowest Solar Altitude during the Solar Noon? At what time and on which day does this Solar Noon occur?
  
10. The actual time for the 2011 Vernal Equinox is 19:21. Examine your data for this day and time and describe what the Sun will look like *at the North Pole* at 19:21. Note: The angular diameter of the Sun is  $0.5^\circ$ .
  
11. Which location has the highest Solar Altitude during the Solar Noon? At what time and on which day does this Solar Noon occur?
  
12. Describe what December 21, 2010 would have been like if you were living at the South Pole as far as the behavior of the Sun? Be as detailed as possible.
  
13. During the Equinoxes, why doesn't the sun rise at exactly 06:00 and set at exactly 18:00 for each location?

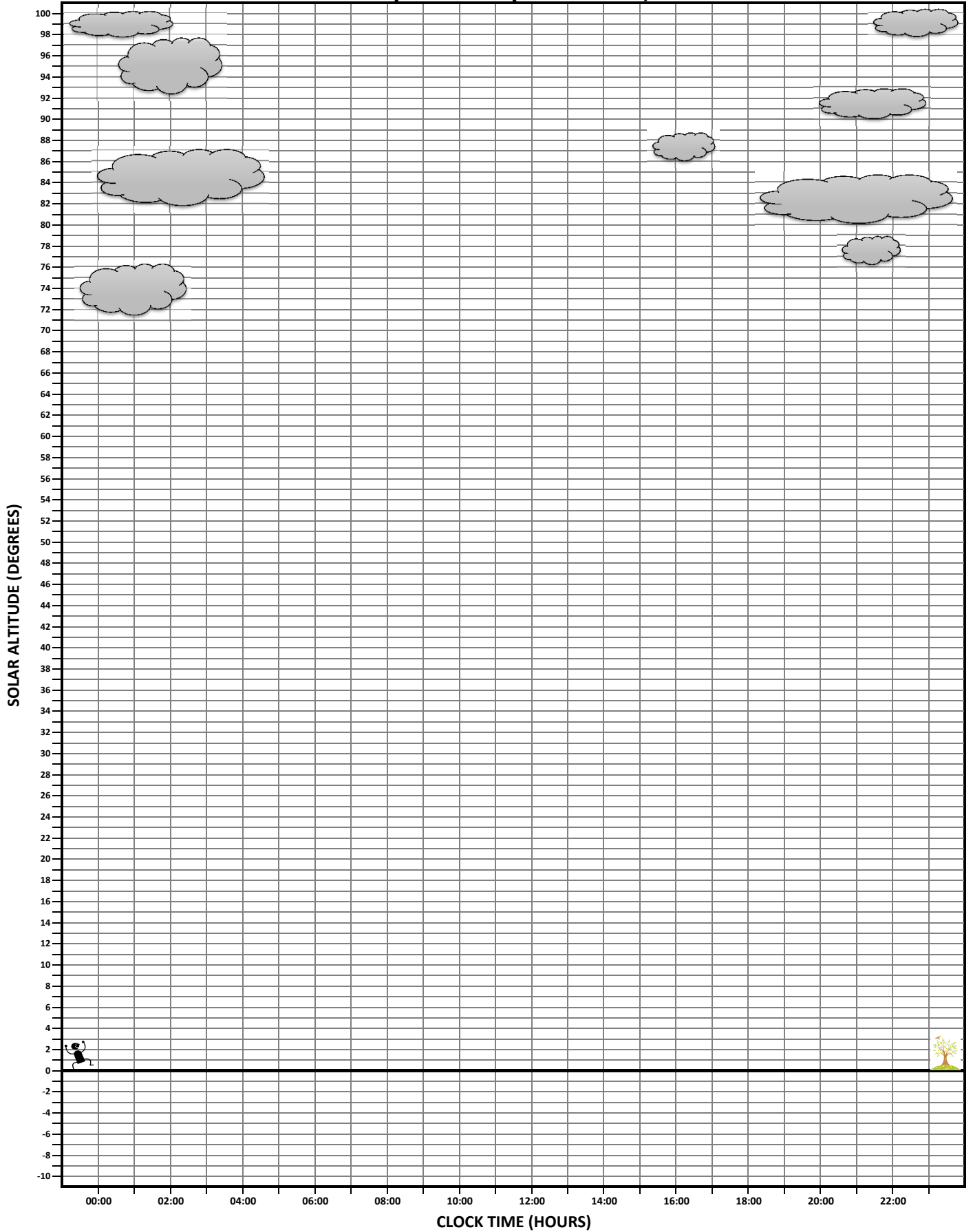
# Summer Solstice - June 21, 2010



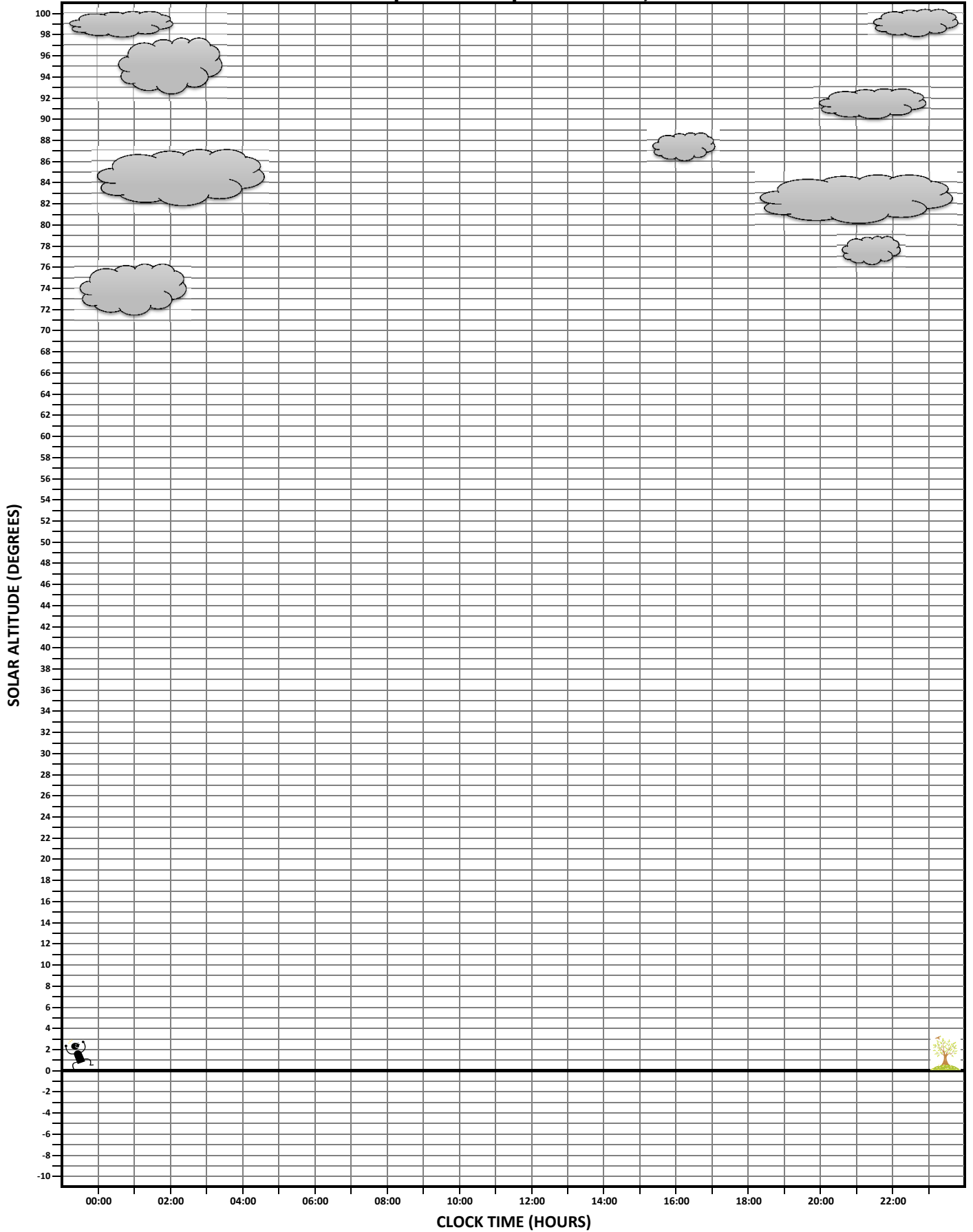
# Summer Solstice - June 21, 2010



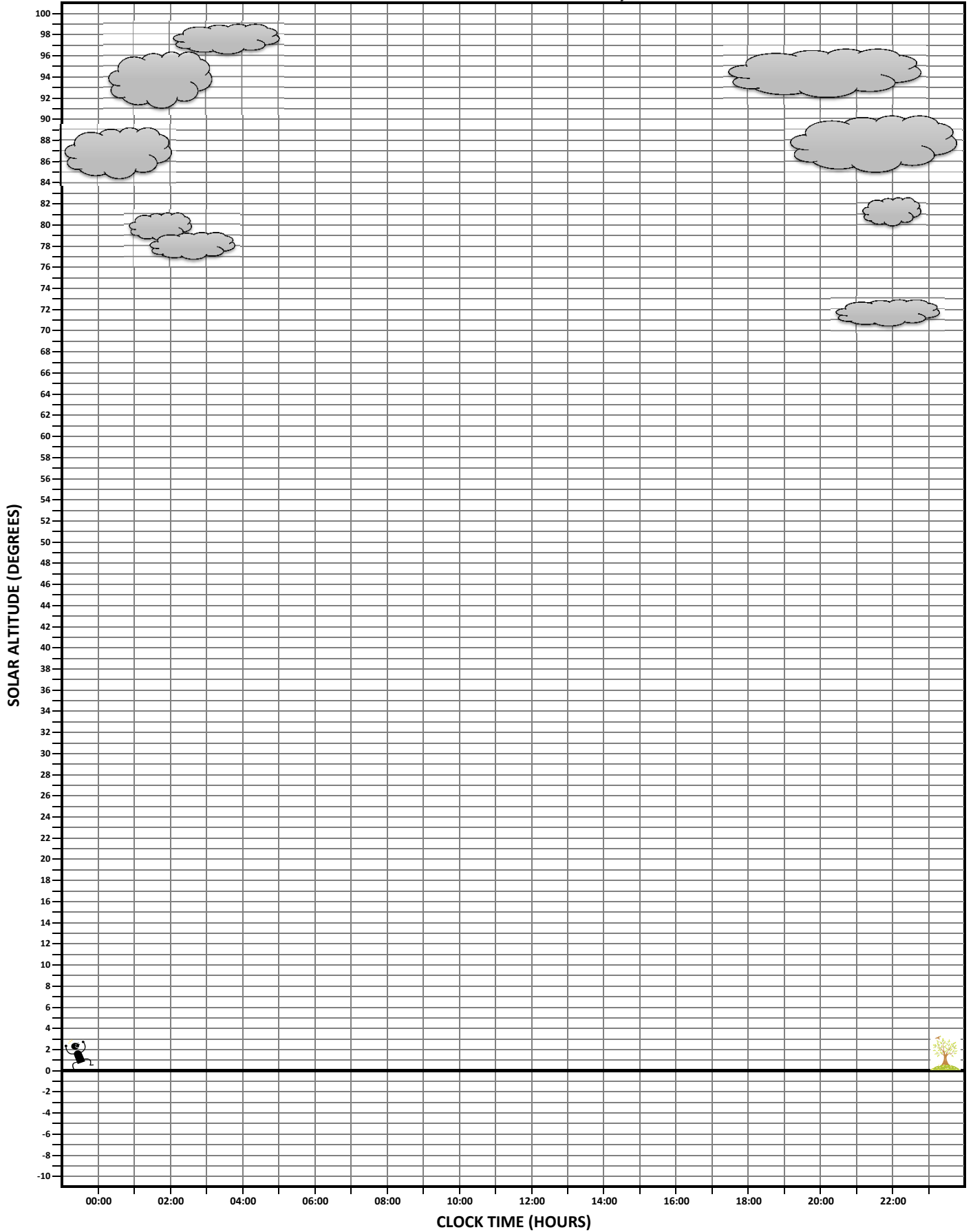
# Autumnal Equinox - September 22, 2010



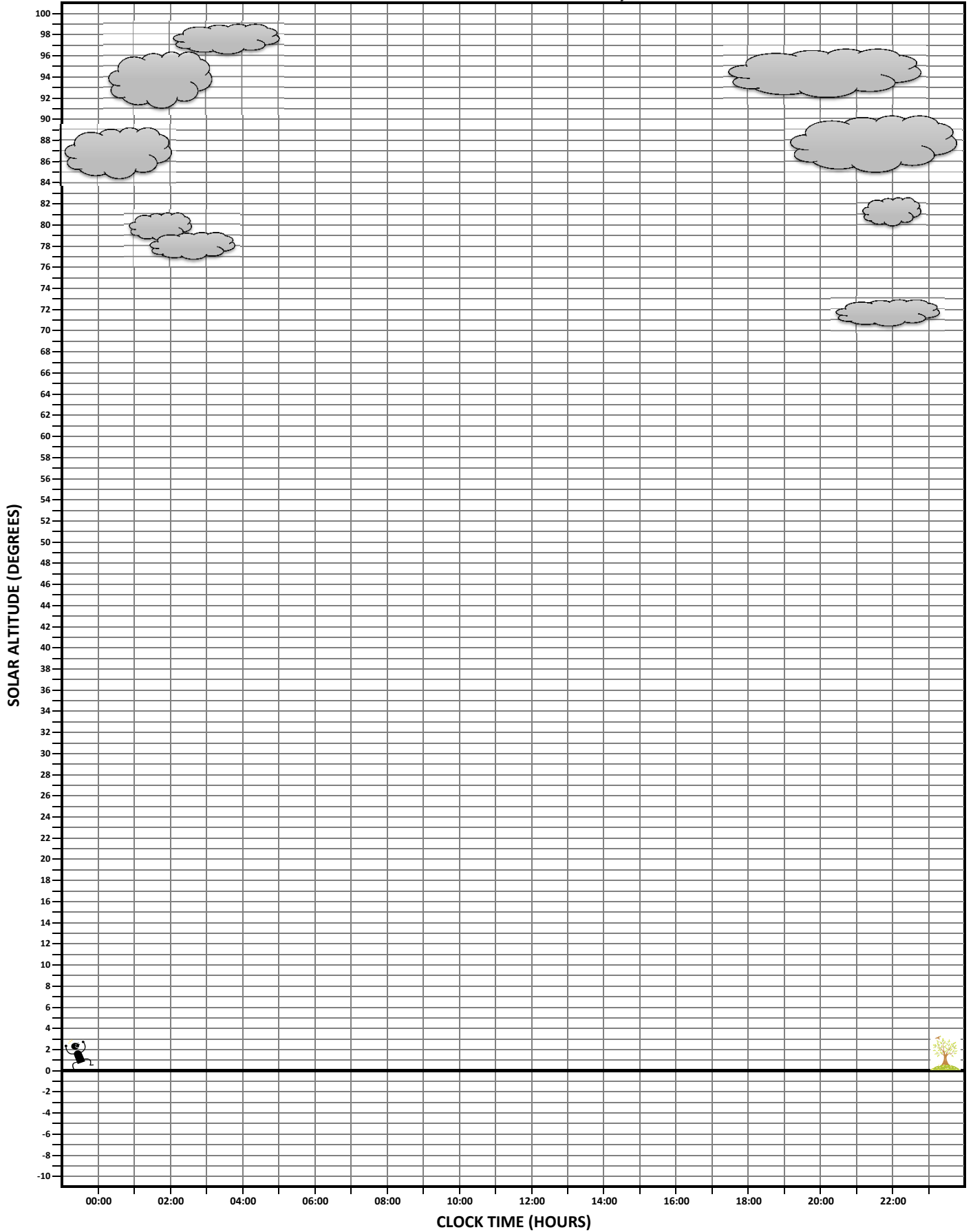
# Autumnal Equinox - September 22, 2010



# Winter Solstice - December 21, 2010

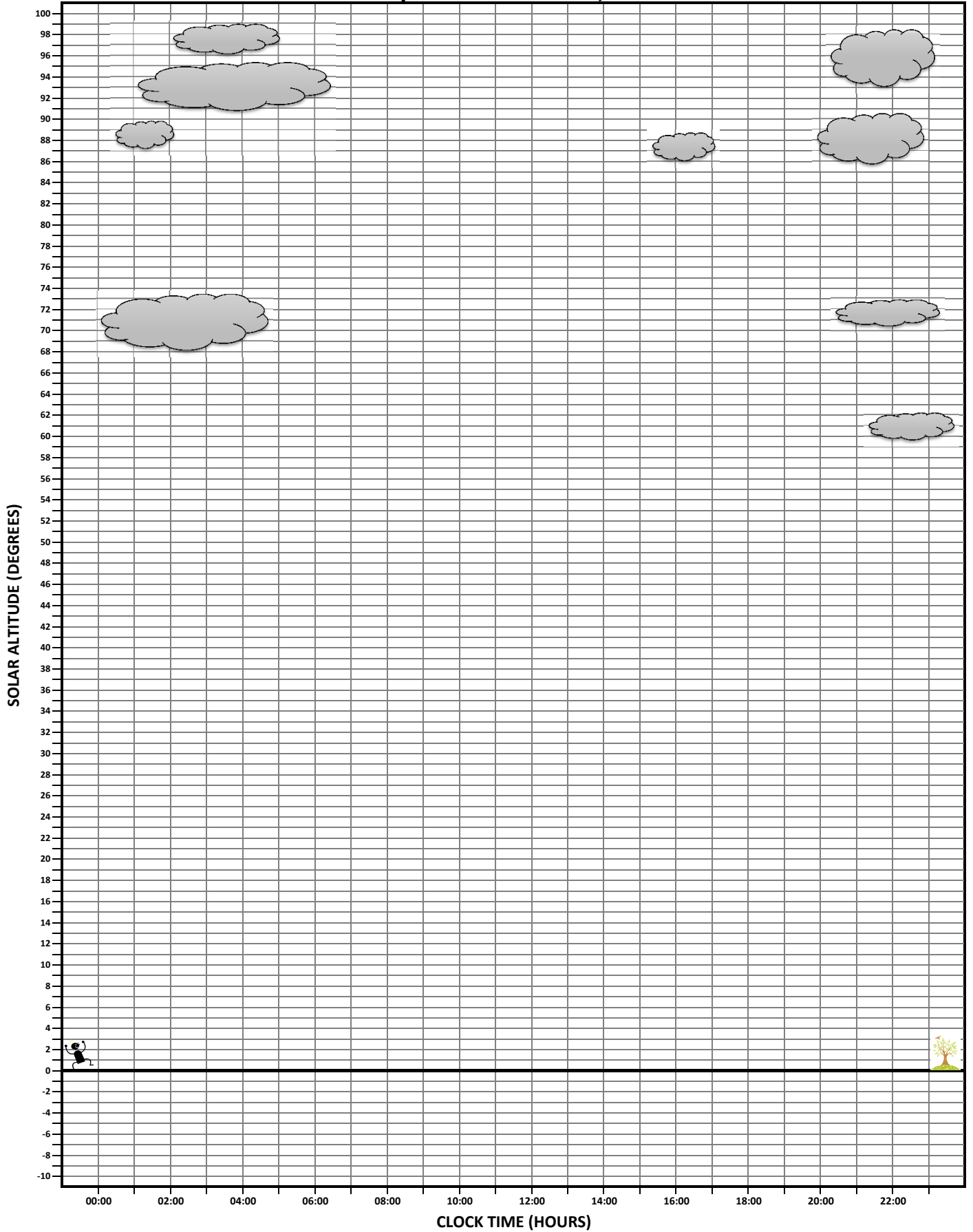


# Winter Solstice - December 21, 2010

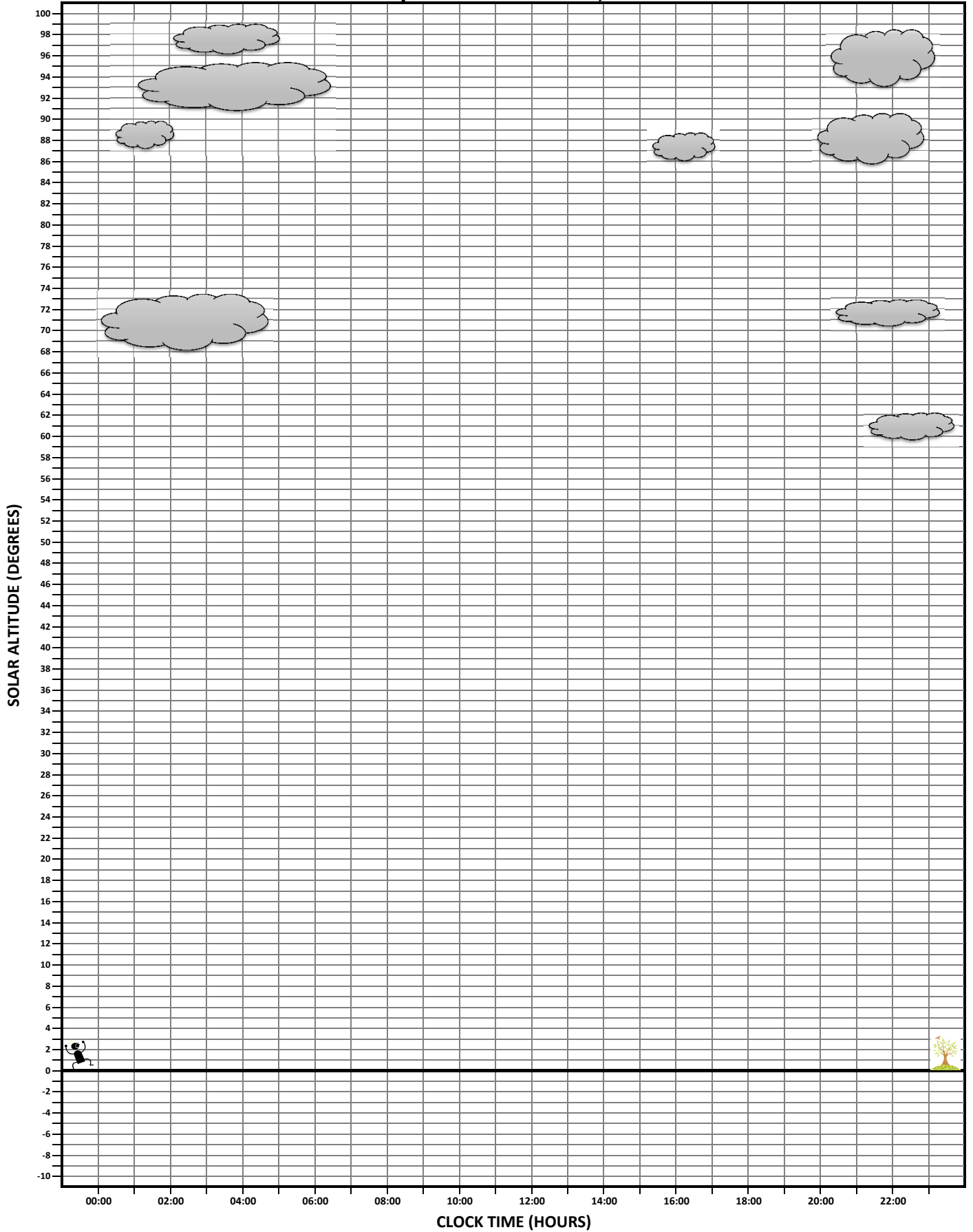




# Vernal Equinox - March 20, 2011



# Vernal Equinox - March 20, 2011



## Solar Altitude Table

Date	Clock Time	Stoneham, MA (42.5°N, 71.1°W)	The Equator (0.0°N, 71.1°W)	Lepá, Argentina (42.5°S, 71.1°W)	The North Pole (90.0°N, 71.1°W)
June 21, 2010	0000				23.5
June 21, 2010	0100				23.5
June 21, 2010	0200				23.5
June 21, 2010	0300	-10.4			23.5
June 21, 2010	0400	-1.9			23.5
June 21, 2010	0500	7.8	-10.6		23.5
June 21, 2010	0600	18.1	3.4		23.5
June 21, 2010	0700	28.9	16.9	-3.1	23.5
June 21, 2010	0800	39.9	30.4	6.1	23.5
June 21, 2010	0900	50.8	43.4	13.8	23.5
June 21, 2010	1000	60.9	55.2	19.7	23.5
June 21, 2010	1100	68.7	64.0	23.2	23.5
June 21, 2010	1200	70.8	66.3	24.0	23.5
June 21, 2010	1300	65.6	60.5	21.9	23.5
June 21, 2010	1400	56.4	50.0	17.3	23.5
June 21, 2010	1500	45.9	37.5	10.5	23.5
June 21, 2010	1600	34.9	24.3	2.2	23.5
June 21, 2010	1700	23.9	10.7	-7.7	23.5
June 21, 2010	1800	13.2	-3.2		23.5
June 21, 2010	1900	3.4			23.5
June 21, 2010	2000	-6.0			23.5
June 21, 2010	2100				23.5
June 21, 2010	2200				23.5
June 21, 2010	2300				23.5
September 22, 2010	0000				0.8
September 22, 2010	0100				0.8
September 22, 2010	0200				0.8
September 22, 2010	0300				0.8
September 22, 2010	0400				0.7
September 22, 2010	0500	-6.7	-9.3	-7.0	0.7
September 22, 2010	0600	4.6	5.9	4.2	0.7
September 22, 2010	0700	15.4	20.8	15.0	0.7
September 22, 2010	0800	25.7	35.7	25.4	0.7
September 22, 2010	0900	35.0	50.7	34.6	0.7
September 22, 2010	1000	42.4	65.7	42.1	0.7
September 22, 2010	1100	46.9	80.7	46.5	0.6
September 22, 2010	1200	47.4	84.3	47.0	0.6
September 22, 2010	1300	43.8	69.3	43.5	0.6
September 22, 2010	1400	36.9	54.3	36.7	0.6
September 22, 2010	1500	27.9	39.3	27.8	0.6
September 22, 2010	1600	17.8	24.3	17.6	0.6
September 22, 2010	1700	7.0	9.3	6.9	0.6
September 22, 2010	1800	-4.2	-5.8	-4.3	0.5
September 22, 2010	1900				0.5
September 22, 2010	2000				0.5
September 22, 2010	2100				0.5
September 22, 2010	2200				0.5
September 22, 2010	2300				0.5

## Solar Altitude Table

Date	Clock Time	Stoneham, MA (42.5°N, 71.1°W)	The Equator (0.0°N, 71.1°W)	Lepá, Argentina (42.5°S, 71.1°W)	The North Pole (90.0°N, 71.1°W)
December 21, 2010	0000				
December 21, 2010	0100				
December 21, 2010	0200				
December 21, 2010	0300			-9.9	
December 21, 2010	0400			-1.3	
December 21, 2010	0500		-9.7	8.4	
December 21, 2010	0600		4.2	18.7	
December 21, 2010	0700	-2.5	17.8	29.6	
December 21, 2010	0800	6.7	31.2	40.6	
December 21, 2010	0900	14.3	44.2	51.5	
December 21, 2010	1000	20.0	55.8	61.5	
December 21, 2010	1100	23.4	64.4	69.0	
December 21, 2010	1200	24.0	66.2	70.6	
December 21, 2010	1300	21.8	60.0	65.1	
December 21, 2010	1400	16.9	49.3	55.8	
December 21, 2010	1500	10.0	36.7	45.2	
December 21, 2010	1600	1.7	23.4	34.2	
December 21, 2010	1700	-8.2	9.9	23.2	
December 21, 2010	1800		-4.0	12.6	
December 21, 2010	1900			2.8	
December 21, 2010	2000			-6.5	
December 21, 2010	2100				
December 21, 2010	2200				
December 21, 2010	2300				
March 20, 2011	0000				0.2
March 20, 2011	0100				0.2
March 20, 2011	0200				0.3
March 20, 2011	0300				0.3
March 20, 2011	0400				0.3
March 20, 2011	0500	-9.7		-9.4	0.3
March 20, 2011	0600	1.7	2.3	1.9	0.3
March 20, 2011	0700	12.4	17.1	12.7	0.3
March 20, 2011	0800	22.9	32.0	23.2	0.3
March 20, 2011	0900	32.6	47.0	32.8	0.4
March 20, 2011	1000	40.5	62.0	40.8	0.4
March 20, 2011	1100	45.9	77.0	46.1	0.4
March 20, 2011	1200	47.4	88.0	47.6	0.4
March 20, 2011	1300	44.8	73.0	44.9	0.4
March 20, 2011	1400	38.7	58.0	38.8	0.4
March 20, 2011	1500	30.2	43.0	30.2	0.4
March 20, 2011	1600	20.3	28.0	20.3	0.5
March 20, 2011	1700	9.6	13.0	9.6	0.5
March 20, 2011	1800	-1.5	-2.0	-1.5	0.5
March 20, 2011	1900				0.5
March 20, 2011	2000				0.5
March 20, 2011	2100				0.5
March 20, 2011	2200				0.5
March 20, 2011	2300				0.6