Lab 1 Supporting Materials & Hints

Question 1) Appendix B.8 – significant figures

Question 2) Appendix B.10 – scientific notation

Question 3) Appendix B.3, B.6, B.8 – math & sig. figs.

Question 4) Lab 1 information - converting

Question 5) Appendix C.1 - Units, Dimensions, Conversions
(page C-1) Understand Quantity, Dimension, Units, in their Basic & Derived forms

Question 6) Lab 1 info & Appendix C – converting; use unit definitions for converting whenever possible

Question 7) Lab 1 info, text Appendices – converting time

Question 8) Appendix B.7, B.5 – graphing /time series graphs

Question 9) Appendix B.7 & Lab 1 info – graphing times series graphing spatial data, & contouring

Questions 10 & 11) Lab 1 info, lecture info & text readings

Lab 1 Tips: Questions 1) & 3), Significant Figures….

Significant Figure Rules Summary (see Appendix B.8 for examples and details)

1) All non-zero numbers (1,2,3,4,5,6,7,8,9) are significant.

2) Zeros: See Appendix B for more examples and explanation; it helps to convert number to their scientific notation to analyse zeros.
    - Zeroes between non-zero numbers are significant.
    - Zeroes that follow the decimal point at the end of a number are significant.
    - Zeros used to locate the decimal point are not significant (e.g. both 3 centimetres and 0.03 meters have only 1 sig. fig.).
    - Zeroes that are part of a number and are located before a "written" decimal point are significant (i.e. the number of significant figures in 200. is 3 while the number in 200 it is only 1. As the decimal is not "written" in the later example, the zeros in 200 are only place holders and are not significant.)

3) Certain values, such as those that arise from the definition of a term (i.e. many constants) are exact numbers and are considered to have an infinite number of significant figures following the decimal point (e.g. by definition there areexactly 1000 ml in a litre).

4) The result of an addition and/or subtraction operation is reported to the same number of decimal places as that in the term with the least number of decimal places (so the number of decimal places in the calculation terms limit the significant figures in your final result).

5) The result of a multiplication and/or division operation is rounded off to the same number of significant figures as possessed by the least precise value in the calculation (here you count the number of significant digits in each value in the calculation and this limits the number of significant figures in your final result.)

6) Often the answer to a calculation contains more digits than are significant. The following rules are used to round-off final answers to their correct number of digits.
    - If the digit following the last number to be retained is less than 5, all the unwanted digits are discarded and the last number is left unchanged.
    - If the digit following the last number to be retained is greater than 5, the last digit is increased by 1 and the unwanted numbers are discarded.
    - If the digit following the last number to be retained is a 5 then you can either round up or down*.

        *How you round only matters when you are rounding multiple results as your rounding process can have cumulative bias when dealing with more than one value. To avoid this, a common rule to use when the number following the last digit to be retained is a 5, is to look at the first digit that won't be retained: if it is an odd number, increase the last digit to be retained by l; if it is an even number, do nothing except discard the numbers that aren't retained. Zero is considered to be an even number.

*** Sig.Figs. Key Confusions ***

1. **When adding or subtracting**, the term with the least number of decimal places determines the significant figures in your final answer (i.e. the least number of decimal places in the calculation values limits the number of significant figures in your final result).

2. **When multiplying or dividing**, the term with the least precise value determines the number of significant figures in your final answer (i.e the least number of significant digits in the calculation values limits the number of significant figures in your final result).

*** Sig.Figs. Key Confusions***

3. **Don’t round internally!** Keep all digits as you calculate results; only your final result is rounded for the correct number of significant figures.

Avoid internal rounding errors by reporting answers twice!

- First calculate & report the result without considering significant figures
- Then report the result again after you have evaluated it for significant figures.

E.g. 2.79 mm x 2 = 5.58 mm = 6 mm

4. **Know which conversions & values are definitions**

E.g. 2.54 cm = 1 inch

We’ll try to indicate them as we encounter them in lab work

CONVERTING

Simple example:

You have 30 fingers.

How many hands?

Show your calculation in a clear mathematical way.

Identify the conversion factors:

5 fingers = 1 hand or 1 hand = 5 fingers

These can also be written as:

$$\frac{5\ \text{fingers}}{1\ \text{hand}} \quad \text{or} \quad \frac{1\ \text{hand}}{5\ \text{fingers}}$$

Choose the form that is most useful for obtaining the units you need for your answer.

Answer:

Conversion factor = $\frac{\textbf{1 hand}}{\textbf{5 fingers}}$

$$\textbf{30 } \cancel{\textbf{fingers}} \times \frac{\textbf{1 hand}}{\textbf{5 } \cancel{\textbf{fingers}}} = \textbf{6 hands}$$

This efficiently shows your units & work

Lab 1 Tips: Questions 8) & 9)

Graphing

See Appendix B for more information (B.5 & B.7)

► To create a graph (graph scales given in Lab 1)

- Use indicated scales when given.
- When scales are not given, consider how to appropriately represent the data you are graphing. A graph is an image; you want to accurately & intuitively convey data.
- Consider every axis, do values increase /decrease; represent your data realistically → critical for spatial data!
- Properly title your graph (always have a descriptive title)
- Properly label both graph axes (always have divisions, names, symbols, units, & sometimes we need to report axis scales)
- Consider if you need a legend, other information, etc. to make your graph interpretable.

Graphing & Contouring Question9

See Appendix B for more information (B.5 & B.7)

- Plot your values.
- For spatial data (Question 9), plot station locations as points first → realize you are creating a map
  - Ensure the graph's West to East axis correctly represents the Prince George's space (hint: you need to know how longitude lines work)
  - Then label each point with its name & temperature value to show their locations
- Contour the plotted temperatures in 1-degree intervals (use whole degrees within the range of values)

Lab 1 Tips: Question 9)

How Longitude works…

From socratic.org/questions/how-can-we-use-latitude-and-longitude-to-find-exact-locations-on-the-earth

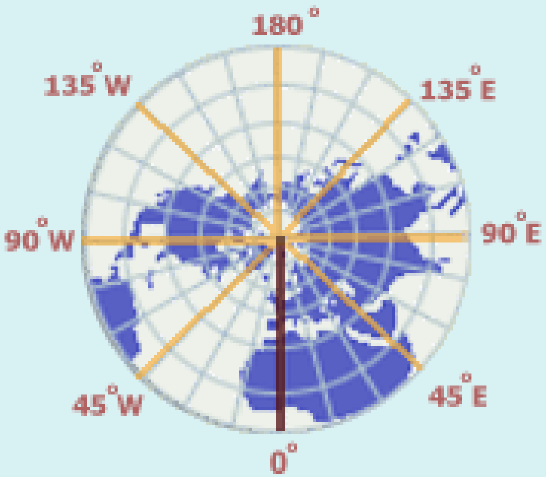
The **Prime Meridian**: Runs through Greenwich England - a suburb of London.

Prime Meridian = 0º W longitude and **0º E longitude and**

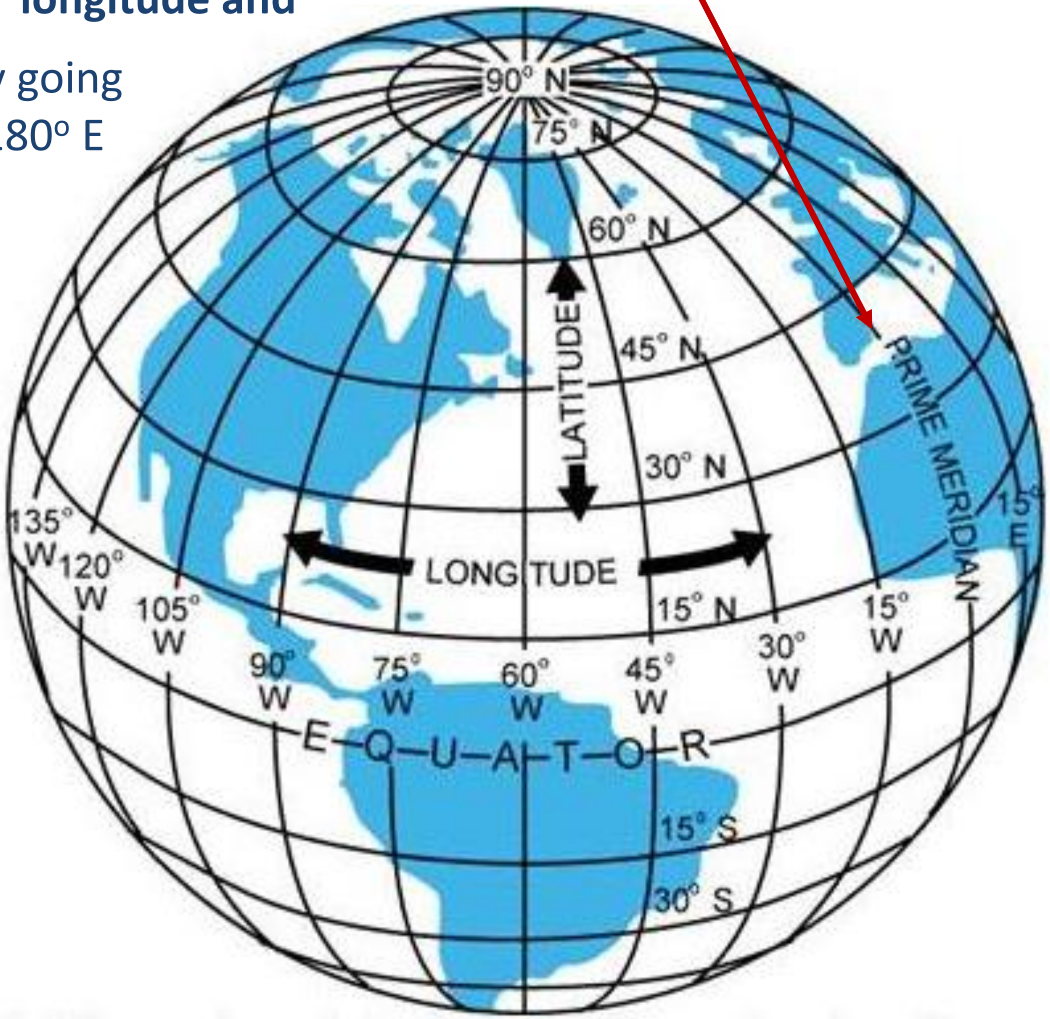
Longitude increases from 0º to 180º W by going to the west. It also increases from 0º to 180º E by going to the east.

Longitude 180º W & 180º E meet in the Pacific Ocean at the **International Date Line**.

International Date Line, 180º



Prime Meridian, 0º



Contouring: Key Concepts

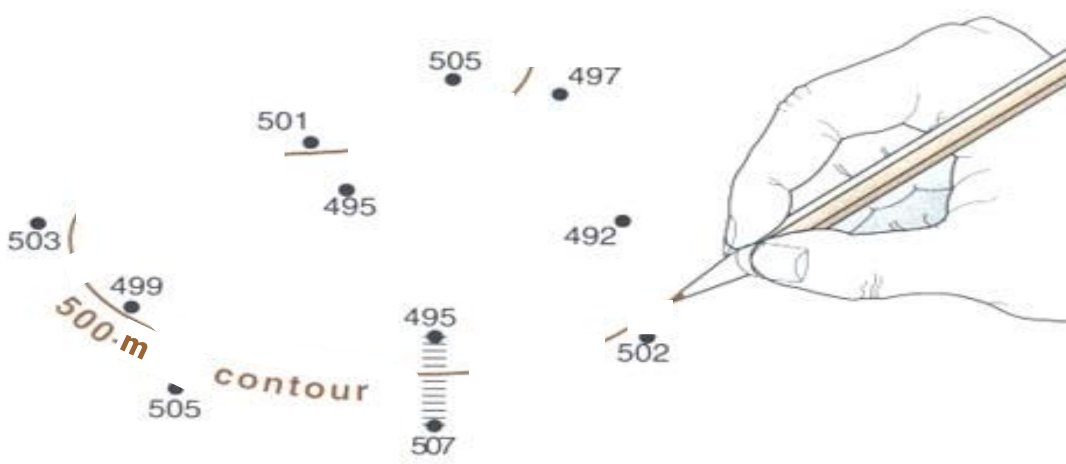
A contour defines and spatially locates a line that has a specific value.

Key Understandings /Rules:

- Determine the contour interval (for us, see the question)
- Contour using whole numbers (8, 9, 10…) spanning the range of provided values
- Start contouring by determining a line in the middle of the range of provided data values. This allows more & better interpolation between known points when placing your contour line.
- The first contour line is hardest to draw.
- Contour lines can not meet.
- Contour lines can not cross each other.
- Appropriately label the contour lines

How to draw contours – review as needed

- Dots are measured data (e.g. elevations)
- Determine contour lines by locating points where a specified value must exist
- Start contouring in the mid-range of your data (see drawing)
- Interpolate between data points to find the locations of a specified value
- Join your interpolations to make a contour line.
- Subsequent lines generally follow the pattern set by the first line, but use the data points to see where the pattern varies.



Earth - Solar Relationships
Working with the Cosine Law of Illumination

Understand Earth's basic coordinate system - longitude & latitude

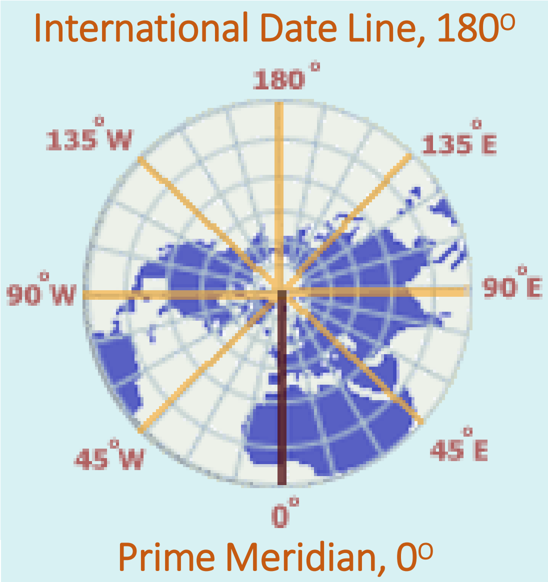
Prime Meridian = 0° West longitude & 0° East longitude

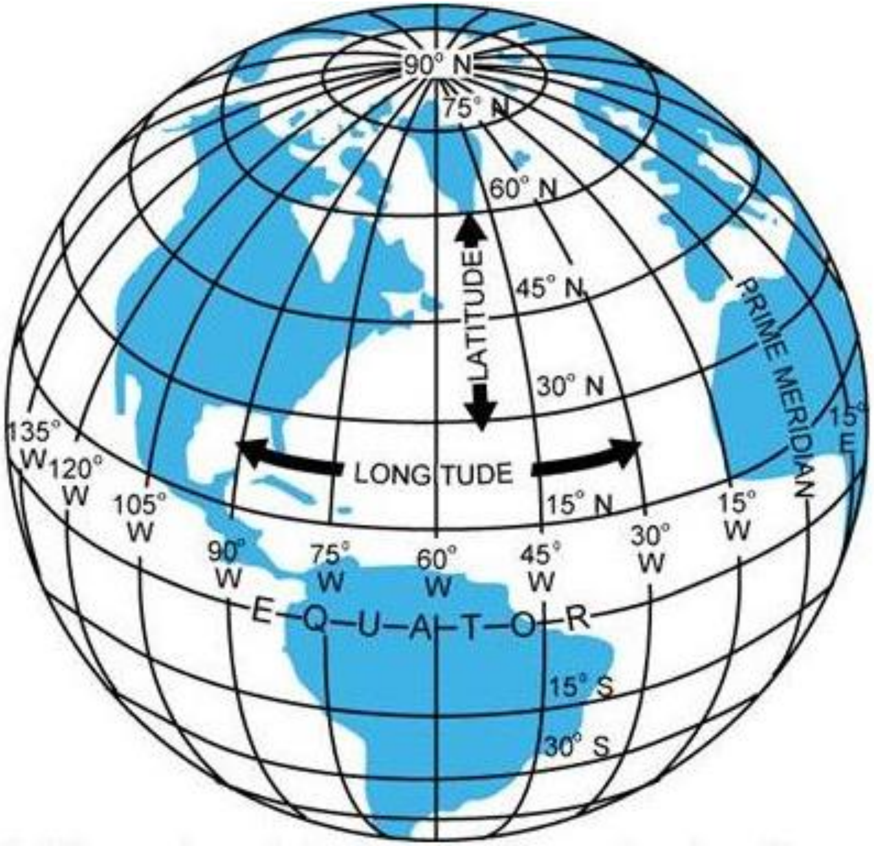
International Date Line = 180° West longitude & 180° East longitude

Equator = 0° latitude

North pole = 90° North latitude

South pole = 90° South latitude





Counting Days & Converting to Julian Days

Julian day (T_J) tallies all the days in a year with January 1 being Julian day 1, February 1 being Julian day 32, and December 31 being Julian day 365, (in a leap Julian day 366).

How to determine a specific Julian Day?

Memorize poems:

Thirty days has September,
April, June, and November;
All the rest have thirty-one,
except
February, which has twenty-eight,
(and in leap years twenty-nine).

Knuckle Calendar Counters:

Your knuckles are the months with 31 days.

The spaces between your knuckles are months with 30 days, except for February which has 28 days (in leap years 29 days).

Questions 10 & 11) to solve:

Understand the Background information, *especially the physical meaning of variables comprising cos Z*

- *What do δ, ø, and h determine or mean?*

Use a globe to visualize Earth-Sun relationships:

- *At what latitudes can the Sun be directly overhead?*
- *How does Earth move each day (on its own, in relation to the Sun)?*
- *How does daily Earth motion affect where a spot on Earth has the Sun directly overhead? How can you identify that spot?*

Use a problem solving approach. Be sure you are calculating the right quantity. Ask questions when confused.*

* *The 4 step problem solving approach: What you are seeking? What information are you given? What additional information do you know? How are what you know & what you are given related (ideally try to draw an figure showing the relationships)?*

Shortwave Radiation Relationships

Cosine Law of Illumination: $I = I_o \cos Z$

where:

$$\cos Z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos h$$

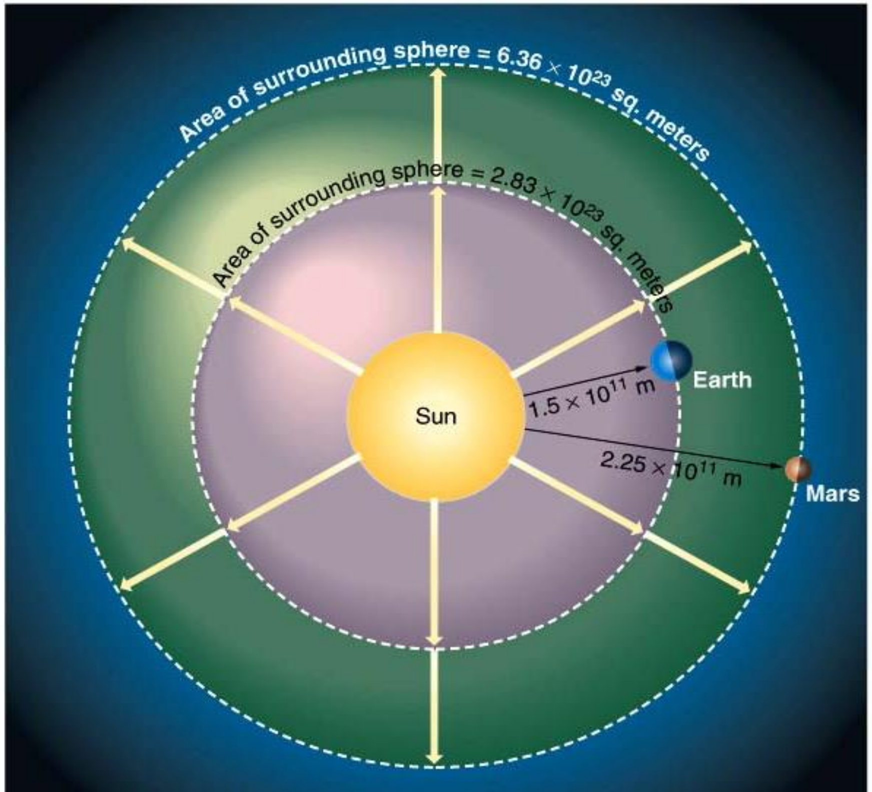
I indicates how much energy is received at a particular time and place on Earth

I_o is the solar constant (from Lecture 1 slides 41 & 42) I_0 = 1361 W m^{-2}

$\cos Z$ considers the:

- latitude where we are measuring solar radiation ($\O$)
- season or time of year - position of the Sun by latitude (δ)
- time of day - position of the Sun by longitude (h)

I_0 → the Solar Constant = 1361 W m^{-2}



Source: Aguado & Burt (2007) Fig 2-9

As solar radiation moves away from the sun it spreads in all directions and reduces intensity.

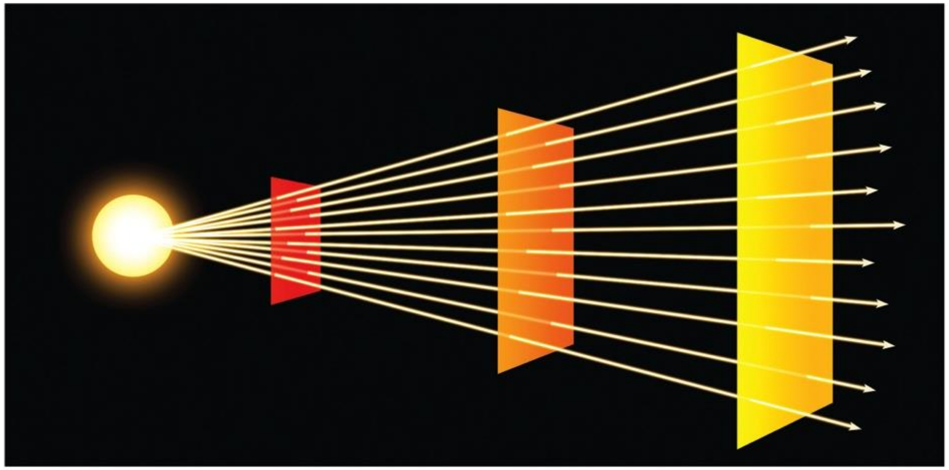


FIGURE 3 The intensity (amount per area) of radiant energy transported by electromagnetic waves decreases as we move away from a radiating object because the same amount of energy is spread over a larger area.

How the Solar Constant is determined (See Lecture 1 slides 41 & 42 for more)

$$I_0 = \frac{3.828 \times 10^{26}\ \text{W}}{(4\pi\,(1.496 \times 10^{11}\text{m})^2)} = 1361\ \text{W m}^{-2}$$

Revisit the definitions at the start of the Lab assignment:

$$\cos Z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos h$$

ø = ***Latitude of your location*** (in degrees)

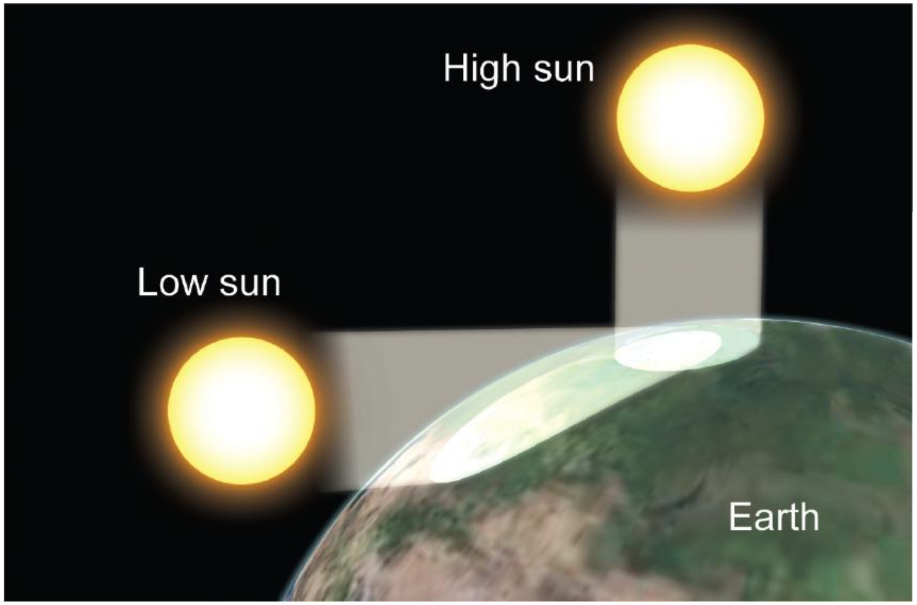
h = ***Hour angle***, which moves 15° for every hour from solar noon. At solar noon, the hour angle is zero, and the Sun is at its highest point in the sky for the day.

δ **=** ***Solar declination*** or the ***latitude where the Sun is directly overhead***. It is measured in degrees North (^{0}N) or in degrees South (^{0}S). A positive value represents a latitude in the northern hemisphere (^{0}N), while a negative value represents a latitude of degrees South.

A reasonable estimate of ***δ*** is calculated by:

$$\delta = -23.4^0 \cos\left(\frac{360(T_J + 10)}{365}\right)$$ where T_J is Julian Day

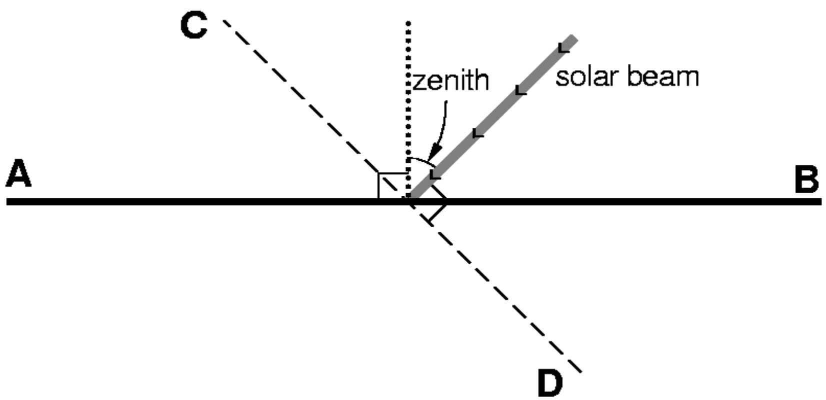
Question 10)



The amount of sunshine received at Earth's surface (***I***) varies with solar angle

(a)

(b)



I = *Radiation flux density at a particular point on Earth's surface due to the angle of the Sun /solar beam (i.e. solar energy reaching Earth due to sun angle – based on your location, the time of year, and time of day).*

Lab 1 Tips…

Question 11)

Use the globe & definitions of each $\cos Z$ term to understand the meaning of each $\cos Z$ component & what it indicates on Earth.