Solar and Terrestrial Radiation

I **Heat and Temperature**

A. _____

1. A form of _____ .

2. The *total* _____ of all the atoms and molecules of a substance

3. Heat always moves from a _____ temperature body to a _____ temperature body.

B. _____

1. The _____ of the individual atoms or molecules in a substance

2. Addition of heat energy causes atoms to _____ and removal causes atoms to _____ down.

3. The total amount of heat of a substance depends upon its _____. For example, a substance can have a *high temperature and small amount* of heat while another may contain a *large amount of heat and have a low temperature*.

4. _____

d. A unit for measuring the quantity of heat when an object is heated or cools off.

e. Defined as the quantity of heat needed to **raise the temperature of one gram of** _____

5. _____

a. Defined as the quantity of heat needed to raise the temperature of _____ by one degree Celsius.

b. The _____the specific heat of a substance, the _____ the amount of heat needed to raise its temperature.

i. Water has the _____ specific heat of all natural substances (1.0 cal/g • C^{o})

ii By comparison the only 0.20 calories are required to heat one gram of the rock basalt one degree Celsius (basalt has a specific heat of _____)

iii Specific heats of some common natural substances are listed in the *Earth Science Reference Tables*.

6 Heat Loss or Gain can be expressed by the following equation.

$$Q = m \_T C_p$$

Where:
Q = total heat lost or gained; m = mass in grams; _T = change in temperature of the substance;
C_p = specific heat of the substance

C. **Methods of Heat Transfer**

1. _____

   a. The transfer of heat through electron and molecular _____ from one molecule to another.
   b. Conduction is important only between Earth's _____ and the air immediately in _____ with the surface.
   c. As a means of heat transfer for the atmosphere as a whole, conduction is the least significant and can be disregarded when considering most meteorological phenomena.

2. _____

   a. Heat transfer that involves movement or circulation of a substance.

   b. Takes place in _____ where the material is able to flow.

   c. _____
      i. Takes place when the fluid near the bottom is heated and becomes _____ dense.
      ii. It rises, cools near the top and continues to "turn over."
      iii. _____ Air moves vertical in the atmosphere. Less dense air rises and transports heat to greater heights.

3. _____

   a. The heat-transfer mechanism by which _____ energy reaches Earth.

   b. Doesn't require a medium in which to travel and can pass through the _____ space.

   c. The Sun emits _____ and _____ along with the rest of electromagnetic spectrum of radiation.

II **Insolation** (**In**coming **So**lar Radia**tion**)

E. _____:

1. Travels out in all directions from the Sun and does travels through the_____ of space.

2. Heat transfer mechanism for_____ energy.

3. The Sun emits _____ wavelengths
   a. Most is concentrated in the _____ (43%) See Rev. Book *Figure 8-1*, page 382.

b. Infrared to visible represents 49%

c. _____represents 7%.

2. *Laws of Radiation*

a. _____objects, at whatever temperature, emit radiant energy.

b. Hotter objects radiate _____ energy per unit area than colder objects

c. The hotter the radiating body, the _____ the wavelength of maximum radiation.

d. Objects that are good absorbers of radiation are also _____.

i. A _____ is considered a perfect absorber and emitter. Earth's surface approaches being a blackbody because it absorbs and radiates with nearly100percent efficiency.

ii. Surface characteristics affect absorption and emission.

(1) Color: _____

(2) Reflectivity

_____

(3) Texture

_____

F. **Intensity of Insolation**

1. This is the _____ at which solar energy is received by a **given** _____ **of Earth's surface per unit of** _____ (usually calories/second/square centimeter).

2. _____: The angle at which the Sun's rays strike Earth's surface.

a. _____**Rays** strike the surface at right angles. They are _____.

b. As the angle **decreases,** the rays become _____**direct** and insolation is spread out over a _____**area**.

c. Therefore, the **more direct the rays** striking Earth's surface, the _____**the intensity of insolation.**

3. Factors Affecting the Angle of Insolation

a. Latitude:

b. Time of Day:

c. Season:

III **The Seasons**

G. _____Observations (Observed from **Earth**) See Rev. Book Figure 9-21 on page 468 and Rev. Book Table 9-3 on page 469.

1. Change in length of _____**.**
2. Change in the sun's _____ across the sky
   a) Change in _____ and _____positions
   b) Change in _____ altitude (solar noon or "high" noon)
      i) Change in angle of _____ of Sun's rays with Earth's surface
      ii) Change in _____ of atmosphere through which the Sun's rays pass

B. Causes of changing the Sun's **noontime altitude** and **diurnal** path throughout the year (See Rev. Book Fig.ure 9-20 on page 467.

1. Earth's _____**to the Sun** continually changes as it _____around the Sun.
2. Earth's axis is inclined _____from a line perpendicular to the plane of it's orbit
3. _____ of Earth's axis:
   G. Earth's axis always points **in the_____ in space**.
   H. The orientation of the axis is at any position in its orbit **always** _____ **to any other position** (See Review Book *Figure 8-6*, page 386).

C. **Solstices and Equinoxes**

1. **Summer Solstice** (Northern Hemisphere):
   a) Northern axis tilts _____ the Sun
   b) Sun's **direct rays** at _____latitude
2. **Winter Solstice** (Northern Hemisphere)

b) Northern axis tilts _____ from the Sun
c) Sun's direct rays at _____ latitude

3. **Equinoxes** (Autumnal and Spring which is also called the *vernal* equinox)
   a) _____ between the solstices
   b) Sun's direct rays _____

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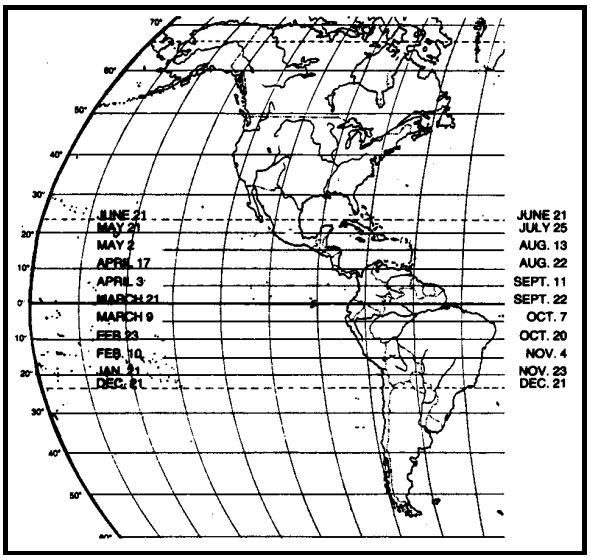
1. Latitude of the Sun's Vertical Rays for Various Dates of the Year

Noon Alt. of Sun = 90^o ***minus*** *the distance in degrees between observer's latitude and the latitude receiving vertical rays for that date.*



IV **The Atmosphere and Insolation** (Refer to Rev. Book Fig. 8-13 on page 398.)

A. What Happens to Insolation?

1. **Scattering**

   a. Insolation is redirected by gases and dust particles (_____) in the atmosphere

   b. Produces _____light.

      i. Degree of scattering depends on _____ of particles or gas molecules

      ii. When light is scattered by very small particles, primarily gas molecules, it is distributed in all directions but most is scattered in the forward direction. Light lost to space is said to be _____.

      iii. **The blue color of the sky**:
      (1) Gas particles more readily scatter shorter wavelengths (blue and violet).
      (2) During midday blue light is seen because it is most readily scatatered.
      (3) When the Sun is lower light travels a longer path.
      (4) _____ color seen because most blue and violet is scattered before reaching the observer.

2. ***Reflection***

   a. Approx. 30% of insolation is reflected back into space by the outer atmosphere.

   b. _____: The fraction reflected by a surface.
      i. Varies with characteristics of the surface.
      ii Varies with weather conditions and time of day and year.

B. **Heating the Atmosphere**

1. _____are the most effective absorbers of radiation and heat the atmosphere
2. The atmosphere is nearly_____ to incoming solar radiation. Direct solar energy is not an effective "heater" of Earth's Atmosphere.
3. The only significant absorbers of insolation are:
   a. _____
   b. _____: High energy, shortwave radiation
   c. _____: High energy, shortwave radiation in the Stratosphere
4. The atmosphere is a relatively efficient absorber of long-wave (infrared) radiation.

C. **Terrestrial Radiation and Heating of the Atmosphere**

1. *Emitted in* _____ *wavelengths*

2. _____ range terrestrial radiation heats the atmosphere. As a result, the atmosphere heats from the ground up.

3. *Normal Lapse Rate*: 6.5^{o} C temperature **decrease** per 1000 meters of altitude. The farther from the source of heat (the ground), the cooler it gets

4. _____ and _____ are principal absorbing gases, accounting for warmer temperatures in the lower troposphere.

D. _____ (Referred to by some scientists as the *Atmosphere Effect*)

1. The transmission of **shortwave** solar radiation by the atmosphere coupled with the selective _____ **of longer-wave** terrestrial radiation, especially by **water vapor** and **carbon dioxide**, resulting in warming of the atmosphere.

2. Effects of cloud cover:
   a) _____ absorbed terrestrial radiation to the surface.
   b) Clear nights vs cloudy nights

   c) Low cloud cover in desert regions results in _____ daily temperature ranges.

V **Earth's Heat Budget**

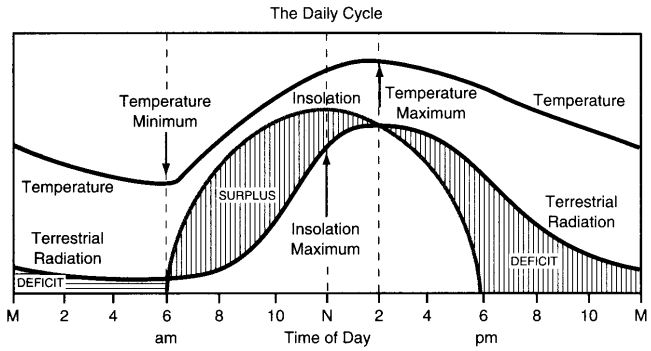
A. **Annual** and **Daily** Balance of Incoming and Outgoing Radiation

1. Surplus

   a. Insolation is _____ than terrestrial radiation.

   a. Temperatures _____ .

   c. The greater the surplus the _____ the rate of temperature increase.

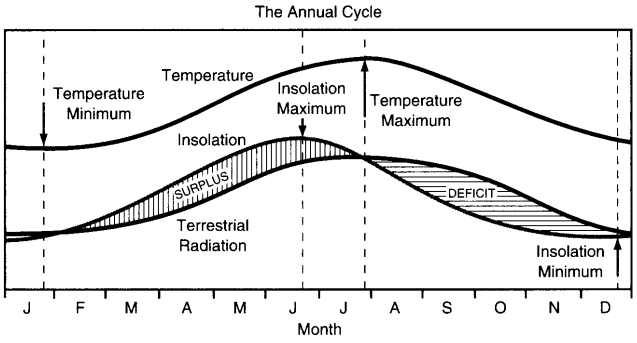


2. Deficit

   a.. Insolation is _____ than terrestrial radiation.

   b. Temperatures _____ .

   c. The greater deficit, the _____the rate of temperature decrease.



3 **Time-Lag** between Maximum Insolation and Maximum Temp. and between Minimum Insolation and Minimum Insolation

B. *Latitudinal Heat Balance* (Heat Equator)

1. **Heat Equator**: A line connecting the highest average temperatures by longitude for a given time period.

2. Observations: