فیزیک جو

درس چهارم

صحرایی

گروه فیزیک دانشگاه رازی

http://www.razi.ac.ir/sahraei

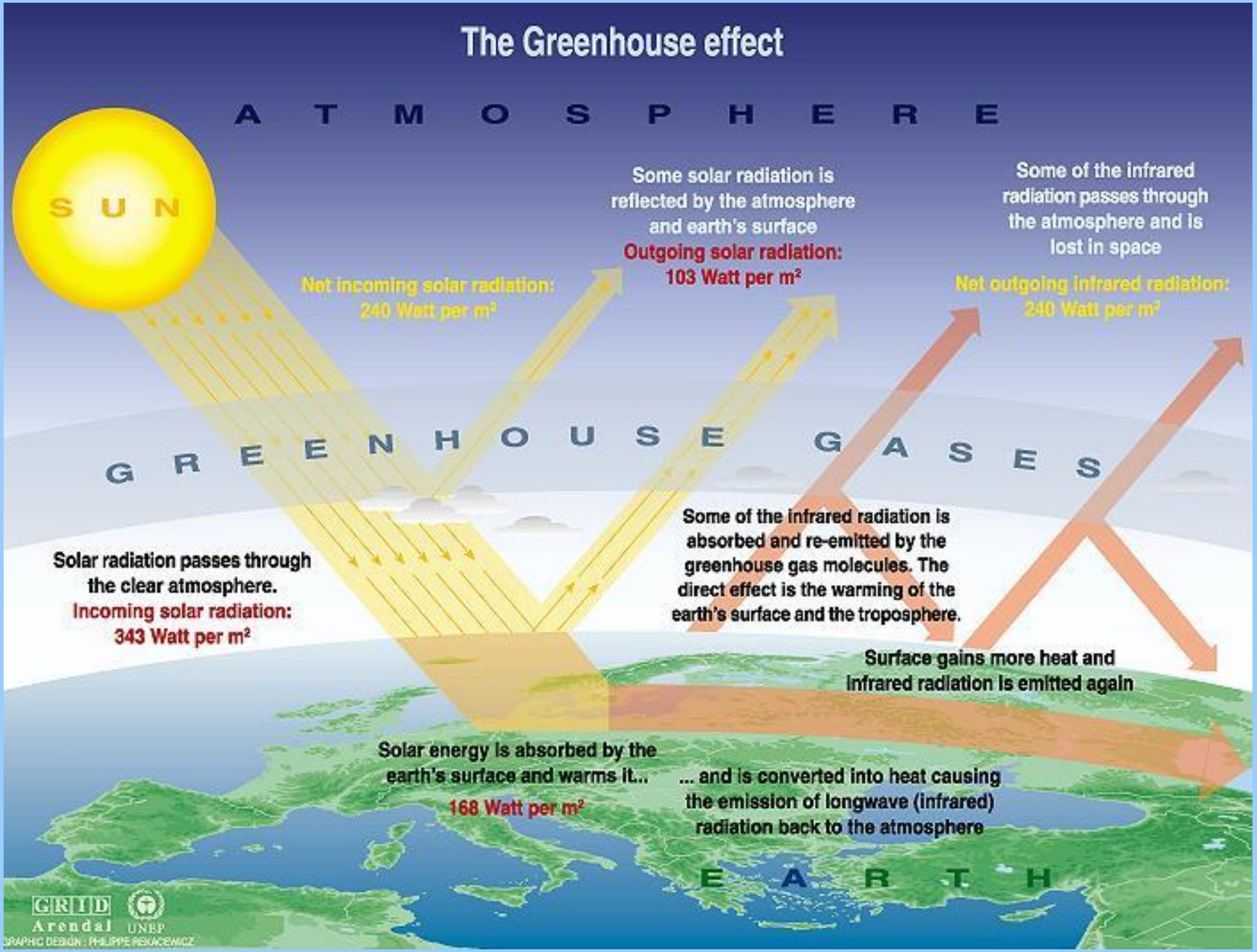
Greenhouse Effect اثر گلخانه ای

اثر گلخانه ای یک پدیده طبیعی است که باعث افزایش دمای سطح زمین می گردد.

غلظت گازهای گلخانه ای در اثر فعالیتهای انسان باعث دمای سطح زمین و بروز مشکلات ویژه می گردد.

- **Important greenhouse gases**
  H_2O, CO_2, CH_4, N_2O, O_3, CFCs
- **Non-greenhouse gases**
  N_2, O_2, H_2, Noble gases

Atmospheric Greenhouse Effect



Scattered Light

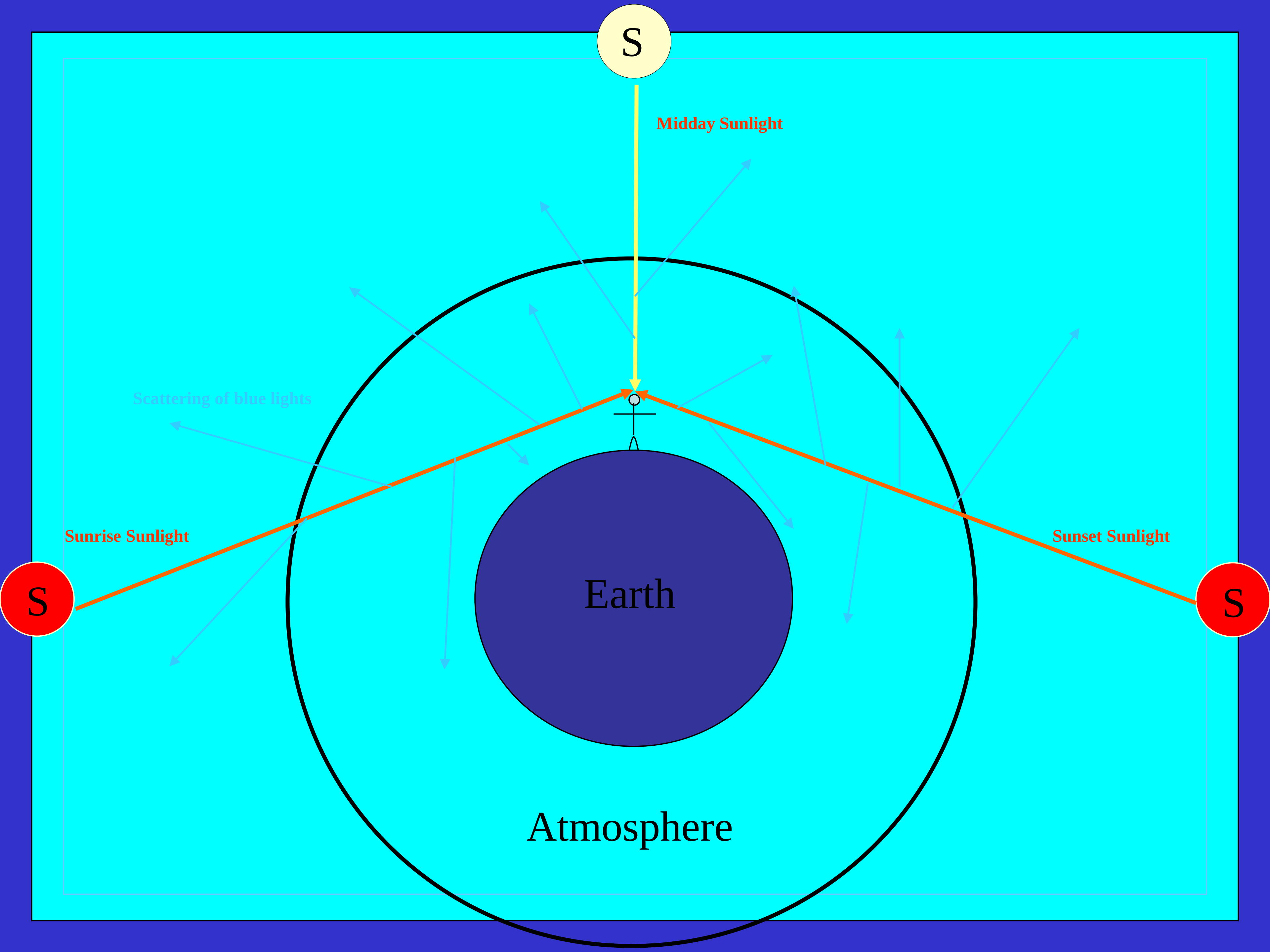
Sunlight passing through earth's atmosphere is deflected by gases, aerosols, and dust in all directions. This distribution of light is called *<u>scattering</u>*.

Air molecules are smaller than visible light wavelengths, therefore they are better scatterers of shorter (blue) wavelengths than longer (red) wavelengths.

At the horizon sunlight passes through more scatterers, leaving longer wavelengths and redder colors revealed.

The midday sun looks white due to less scattering by the air molecules.

<u>Interactions depend on wavelength and type of matter</u>

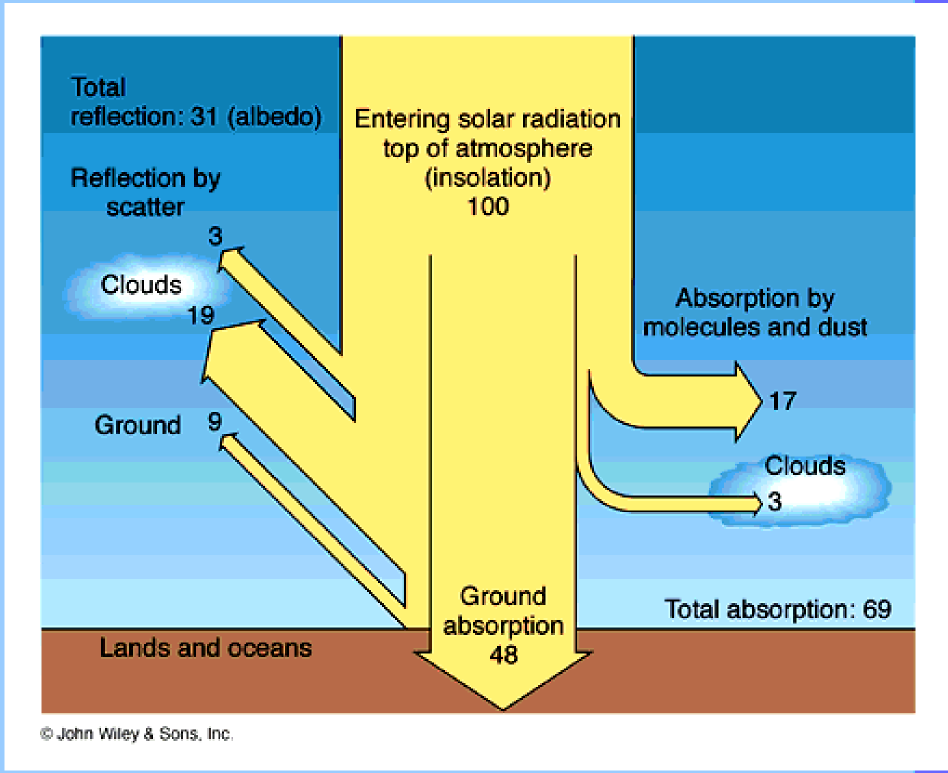

S
Midday Sunlight
Scattering of blue lights
Sunrise Sunlight
Sunset Sunlight
S
S
Earth
Atmosphere

Shortwave Radiation Budget

• Typically, to aid with discussion, we use ‘dimensionless units’ where 100 represents an amount equal to what comes from the sun

Reflection (Albedo):

• 3% reflected to space by atmosphere
• 19% reflected by clouds
• 9% reflected by the surface



Absorption in the atmosphere:

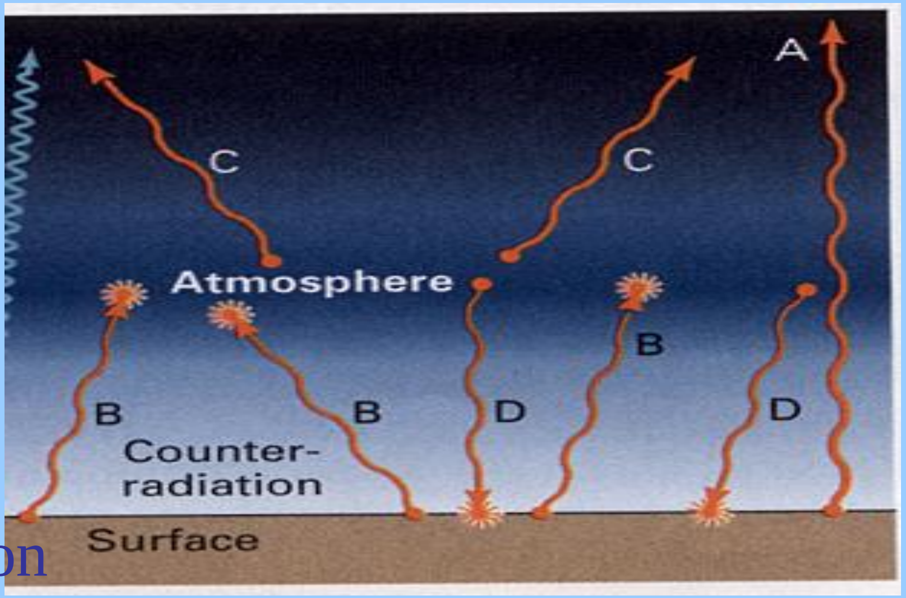
• 18% absorbed by atmosphere
• 3% absorbed by clouds

Absorption by the surface:

• 48% absorbed at the surface
• This radiation is absorbed, heats the surfaceand is converted to
  - Longwave radiation
  - Sensible and latent heat

Albedo is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space.

Longwave Radiation



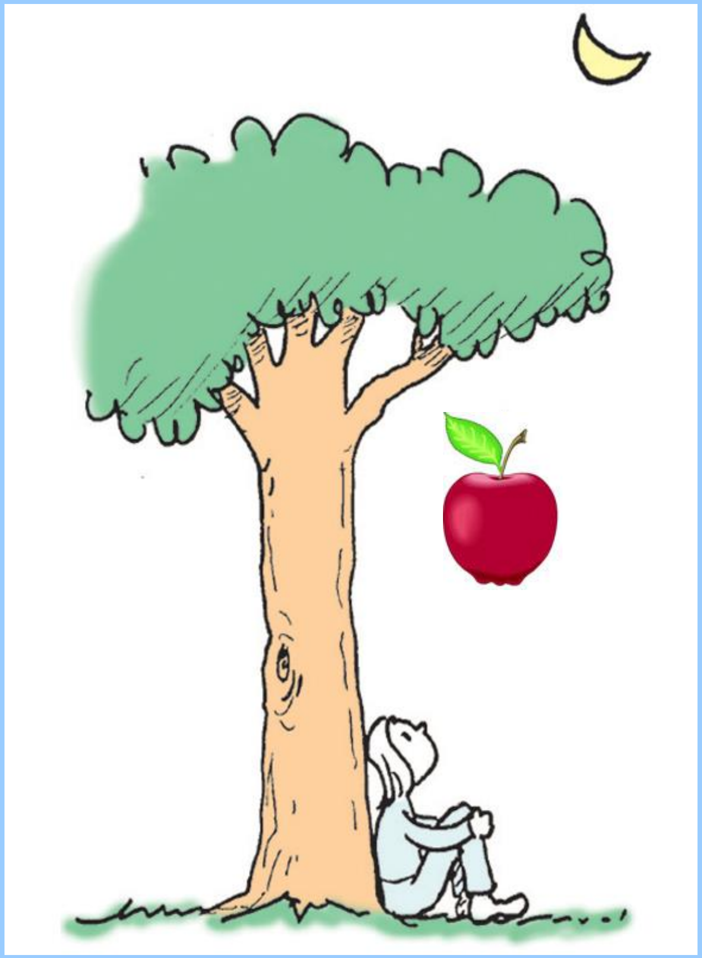
- **The surface emits longwave radiation (A and B), some of which escapes to the free space (A)**

As opposed to solar radiation, the atmosphere is strongly absorptive to longwave radiation

- **Hence, the atmosphere "traps" outgoing longwave flux emitted by the surface (B)**

- This absorbed long-wave radiation goes to heating the gas molecules in the atmosphere
- In turn, the atmosphere emits longwave radiation
  - ➢ Some of this radiation is emitted to space (C)
  - ➢ But some of it is also emitted back towards the earth (D)
- Hence emission of longwave radiation from the atmosphere back to the surface represents **another** form of radiative heating of the surface

پدیده های گرانشی



Due to the earth's gravity, this atmosphere is held to the earth


OMG! TWEET TWEET LOL!
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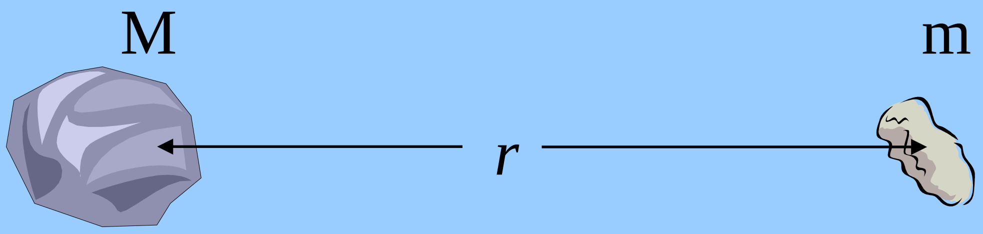
Newton's Law of Universal Gravitation



Between every two objects there is an attractive force, the magnitude of which is directly proportional to the mass of each object and inversely proportional to the square of the distance between the centers of the objects.

$$F \propto \frac{Mm}{r^2}$$

$$F = G\frac{Mm}{r^2}\frac{\vec{r}}{r},$$

$$G = 6.67x10^{-11} N \cdot m^2 / kg^2$$

نیروی گرانشی وارد شده به جرم نقطه ای

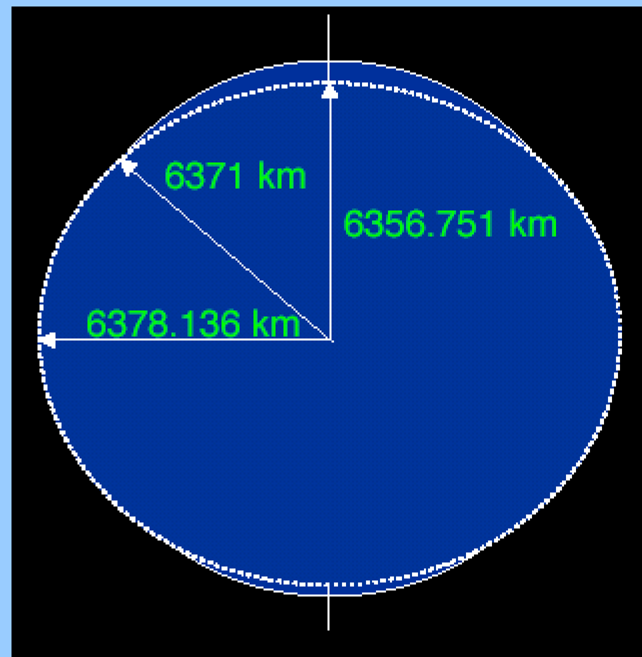
$$\vec{F} = m\vec{g}$$

$$\vec{F} = \vec{g}^{\,*} = G\frac{M}{r^2}\frac{\vec{r}}{r}$$

$$g^* \equiv \frac{GM}{(R+z)^2} \equiv \frac{GM}{\left[R(1+z/R)\right]^2}$$

$$g^* \equiv \frac{GM}{R^2}\frac{1}{(1+z/R)^2} \equiv \frac{g_0{}^*}{(1+z/R)^2}$$

$$R_{pol} = 6356.7\,\mathrm{km}, \quad R_{eq} = 6378.1\,\mathrm{km}$$



$$g_0^{\ *}{}_{pol} = 983.2\ \mathrm{dyn/gr}, \qquad g_0^{\ *}{}_{eq} = 981.4\ \mathrm{dyn/gr}$$

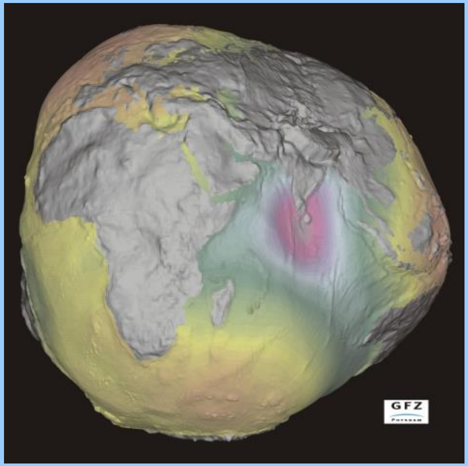
$$f(x) = f(x_0) + (x - x_0) f'(x_0) + \frac{(x - x_0)^2}{2} f''(x_0) + \ldots$$

$$g^* = \frac{g_0^*}{(1 + z/R)^2}$$

$$g^* = g^*_{z=0} + (z - z_{=0}) g'^*_{z=0} + \frac{(z - z_{=0})^2}{2} g''^*_{z=0}$$

$$g^* = g_0^* (1 - \frac{2z}{R})$$

Actually, the Earth is even more odd-shaped and lumpy than the oblate spheroid.



A geoid is a close representation or physical model of the figure of the Earth

The true physical equipotential surface is called the *geoid*.

Gravitation and Gravity

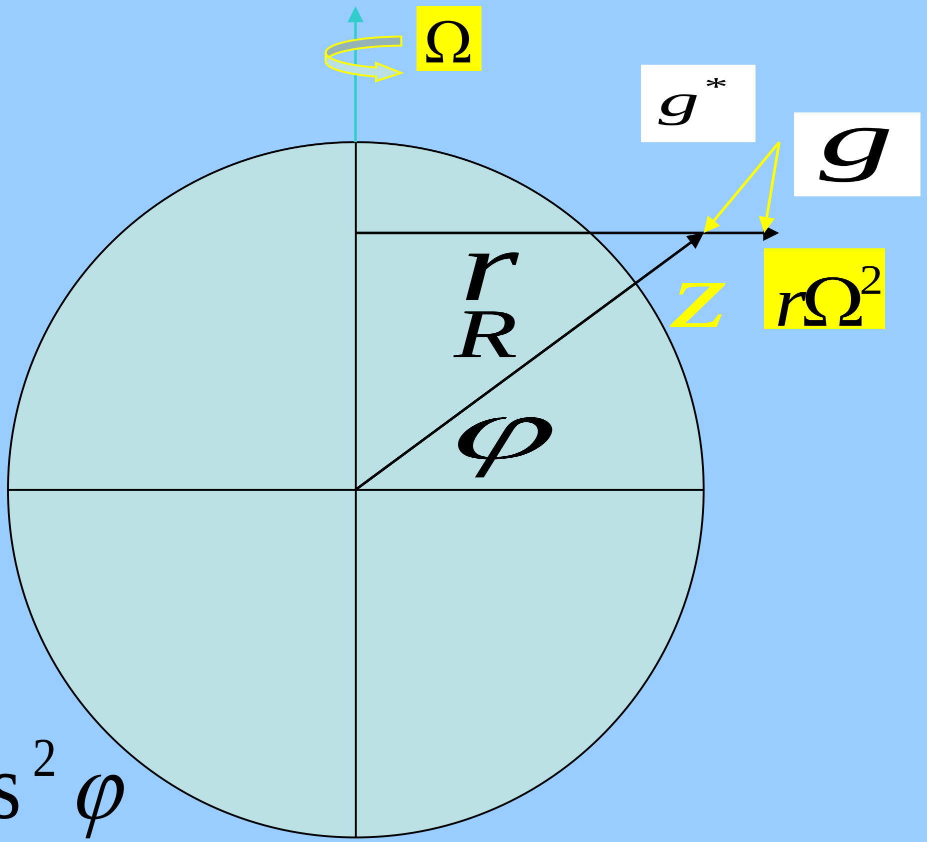
The terms gravity and gravitation are often used to explain the same thing, but there is a definite difference between the two.

Gravitation is the attractive force existing between any two objects that have mass.
The force of gravitation pulls objects together.

Gravity is the gravitational force that occurs between the earth and other bodies.
Gravity is the force acting to pull objects toward the earth.

$$\vec{g} = \vec{g}^{*} + \vec{r}\Omega^{2}$$

$$r = (R+z)\cos\varphi$$



$$g = g^{*} - \Omega^{2}(R+z)\cos^{2}\varphi$$

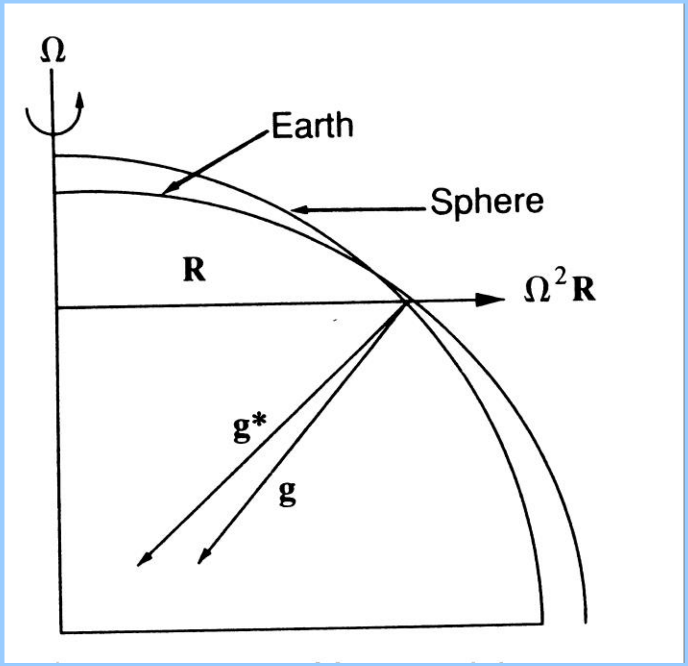
$$g = g^{*}\left(1 - \frac{\Omega^{2}(R+z)\cos^{2}\varphi}{g^{*}}\right)$$

$$\varphi = \pi / 2 \rightarrow g_{pol} = 983.2 \text{ dyn/gr}$$

$$\varphi = \pi / 4 \rightarrow \mathrm{g}_{45} = 980.6 \text{ dyn/gr}$$

$$\varphi = 0 \quad \rightarrow g_{Eq} = 978.4 \text{ dyn/gr}$$

$$\Delta g = g_{pol} - g_{Eq} = 5.2 \text{ cm/s}^2$$



Geopotential

An outstanding example of a conservative field of force is that of gravity.

If we let Φ represent the gravity potential then (The Earth's gravity field can be described by a potential as follows)

$$g = -\nabla\Phi$$

It has the dimensions of energy per unit mass.

The gravity potential is commonly referred to as the **geopotential**.

If we take the *z* axis directed along the plumb line at a given position but opposite to the direction of gravity then we can write for the magnitude of gravity

$$g = \frac{d\Phi}{dz}$$

$$\Phi_2 - \Phi_1 = \int_{z_1}^{z_2} g\,dz$$

Taking Φ arbitrarily zero at the level $z = 0$ (say, mean sea level) gives

$$\Phi = \int_0^z g\,dz$$

Thus Φ is interpreted simply as the potential energy per unit mass by virtue of its relative position in the field of gravity.

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$$g^* = \frac{{g_0}^*}{(1 + z/R)^2}$$

$$g^* = \frac{GM}{(R+z)^2}$$

$$g = g^*\left(1 - \frac{\Omega^2 (R+z)\cos^2\varphi}{g^*}\right)$$

$$\Phi = \int_0^z g.dz$$

$$\Phi = \int_0^z \frac{GM}{(R+z)^2}dz - \int_0^z \Omega^2 (R+z)\cos^2\varphi dz$$

$$\Phi = \frac{GMz}{R(R+z)} - \Omega^2 \cos^2 \varphi (R + z/2) z$$


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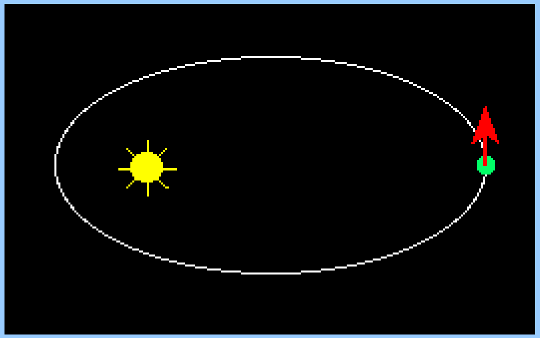
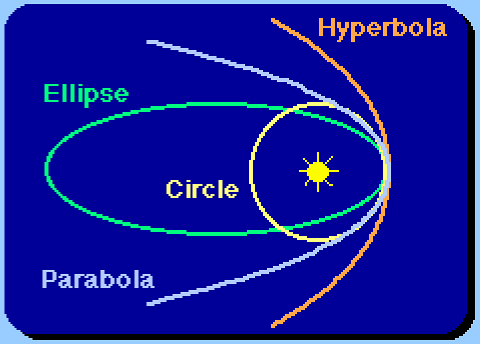
Examples of Gravitational Orbits

We see examples of all these possible orbitals in gravitational fields. In each case, t
he determining factor influencing the nature of the orbit is the relative speed of the object in its orbit.

The orbits of some of the planets (e.g., Venus) are ellipses of such small eccentricity that they are essentially circles, and we can put artificial satellites into orbit around the Earth with circular orbits if we choose.
The orbits of the planets generally are ellipses.
Some comets have parabolic orbits; this means that they pass the Sun once and then leave the Solar System, never to return. Other comets have elliptical orbits and thus orbit the Sun with specific periods.
The gravitational interaction between two passing stars generally results in hyperbolic trajectories for the two stars.





the ultimate Euclidean cloud

دمای پتانسیل

[redacted]

$$k = R / c_p$$

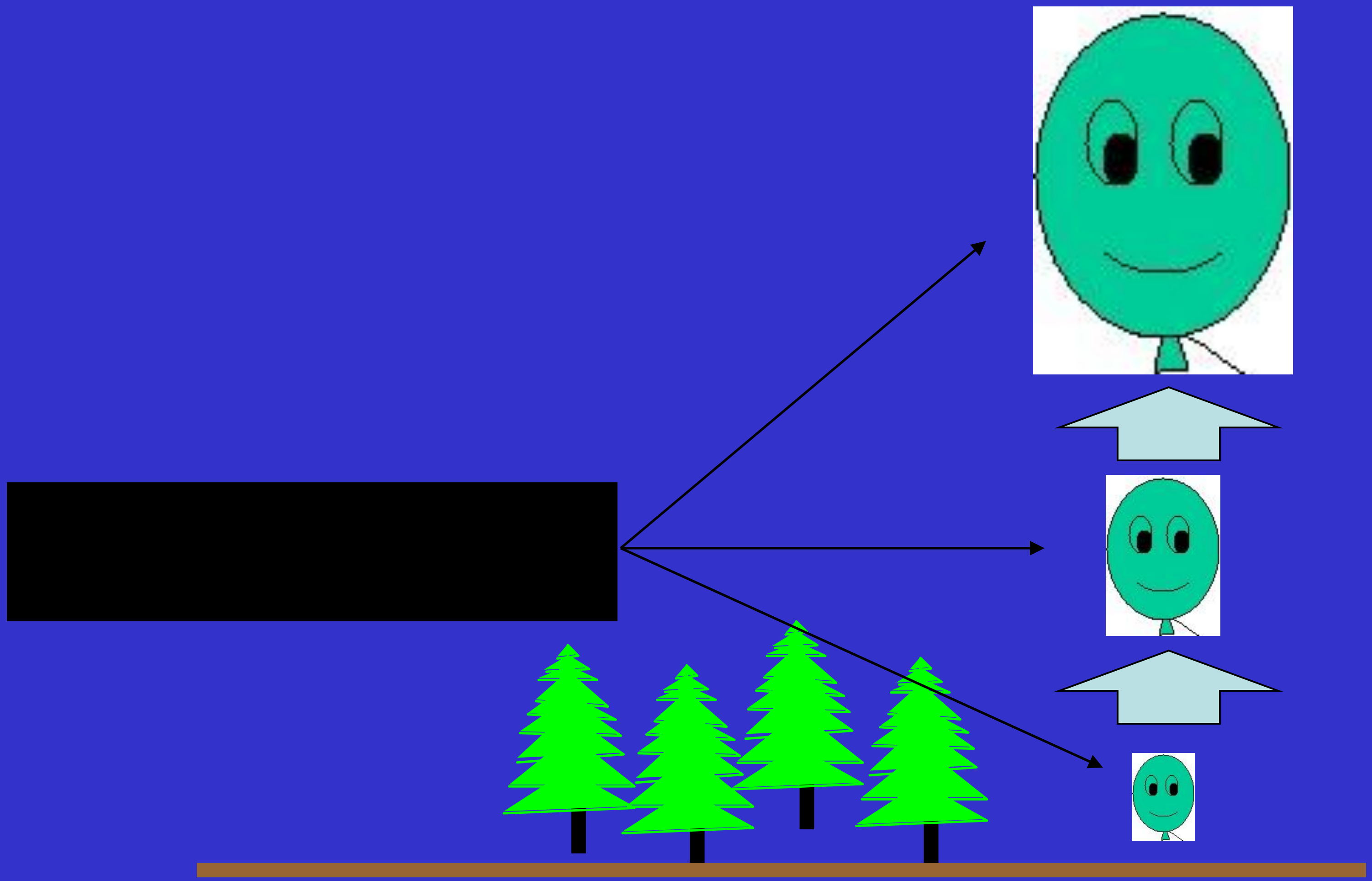
$$\frac{\theta}{1000^k} = \frac{T}{p^k} = cons.$$

$$\theta = T\left(\frac{1000}{p}\right)^k$$

Potential temperature, θ, is a conserved quantity in an adiabatic process.

the temperature a parcel would have if moved to the 1000 hPa level in a dry adiabatic process.

- Potential temperature can act as a *tag* or air *tracer*



DFN: **Potential temperature**, : The temperature that a parcel of air would have if it were brought to the 1000 hPa level (near the surface) in a dry adiabatic process.

$$\theta_z \approx T_Z + Z\gamma_0$$

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