The Upper Atmosphere

Homework #1.

At 200 km altitude the the thermospheric atomic oxygen density is 4.0 x 10^9 cm^{-3}
The atomic oxygen scale height is 50 km.
The Helium Density is $6x10^6$ cm^{-3}
The temperature is independent of height above 200 km

What is the mean molecular weight of these two species at 200 km

$$\bar{M} = \frac{M_{He}N_{He} + M_O N_O}{N_{He} + N_O}$$

$$= \frac{4\times 6\times 10^6 + 16\times 4\times 10^9}{6\times 10^6 + 4\times 10^9} \approx 16$$

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Homework #1.

What is the mean molecular weight of these two species at 600 km

$$\bar{M} = \frac{M_{He}N_{He} + M_O N_O}{N_{He} + N_O}$$

$$N_{He600} = N_{He200}\exp\left(-\frac{400}{H_{He}}\right) \quad ; \quad N_{O600} = N_{O200}\exp\left(-\frac{400}{H_O}\right)$$

$$H_O = 50 \quad ; \quad H_{He} = H_0 \times 4 = 200$$

$$N_{He600} = 6\times10^6\exp(-2) \approx 8\times10^5 \quad ; \quad N_{O600} = 4\times10^9\exp(-8) = 1.4\times10^6$$

$$\bar{M} = \frac{4\times8\times10^5 + 16\times1.4\times10^6}{8\times10^5 + 1.4\times10^6} \approx \frac{256\times10^5}{22\times10^5} \approx 11.6$$

The Upper Atmosphere

Homework #2.

Go to

http://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html

For July 12, 2012 at 15:00 local time and 0° geographic latitude and 180° longitude download an ascii file containing profiles of the following:
The densities of O, O2, N2 and He
The neutral Temperature Tn
At altitudes from 0 to 1000 km with a 5 km step size.

Make a list file to import to excel or any other data manipulation and display software of your choice.

Compute and plot the scale height of atomic oxygen by differentiating the density profile
Compute and plot the scale height of atomic oxygen using the temperature profile.
Comment on any differences you find.

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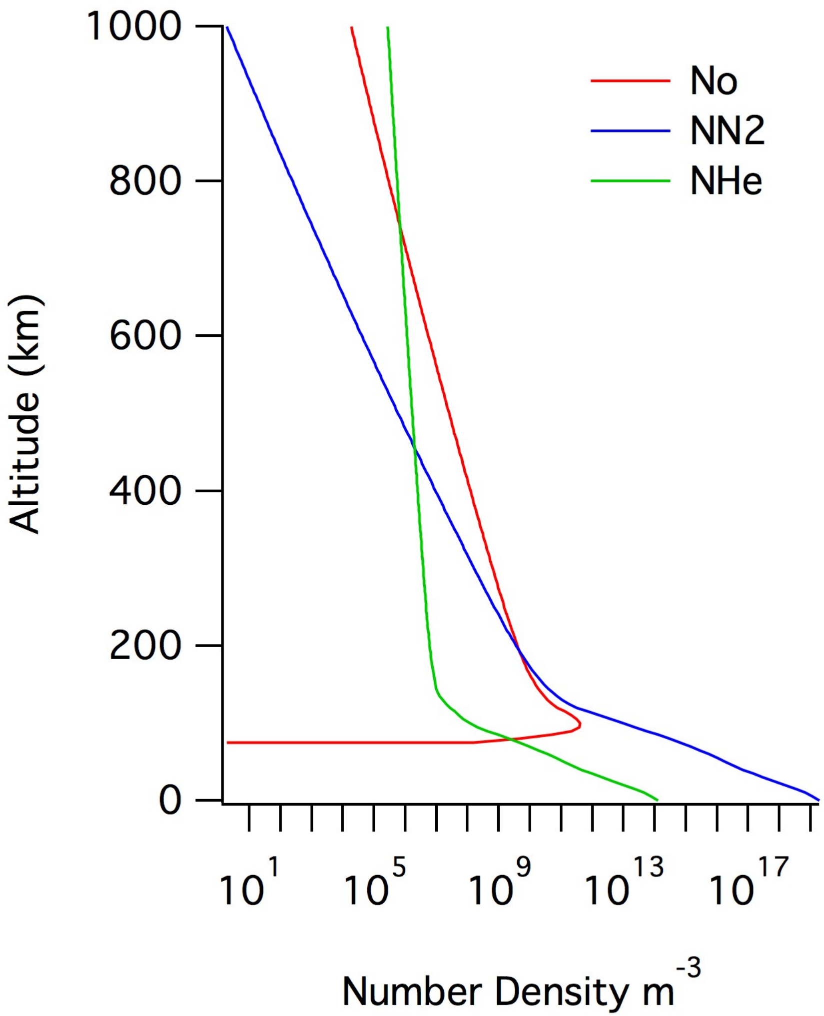
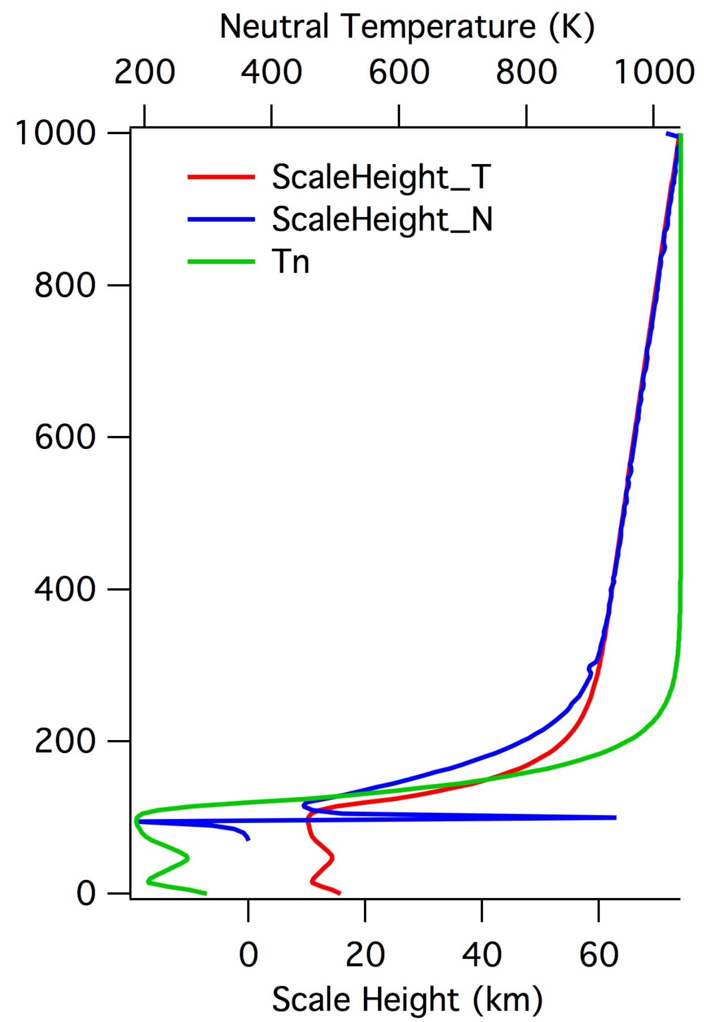
Homework #2.





They are different if you do not account for altitude dependence of temperature and gravity.

The Upper Atmosphere

Homework #3.

The daytime E-region consists of equal concentrations of NO^+ and O_2^+.
These species are lost by recombination with reaction rates of 4×10^{-8} $cm^3 s^{-1}$ and 1×10^{-7} $cm^3 s^{-1}$ respectively.

If the total ion concentration is 4×10^4 cm^{-3} what is the ionization production rate ?

The Upper Atmosphere

Homework #3.

The daytime E-region consists of equal concentrations of NO+ and O2+.
These species are lost by recombination with reaction rates of $4\text{x}10^{-8}$ cm^3s^{-1}
and $1\text{x}10^{-7}$ cm^3s^{-1} respectively.

If the total ion concentration is $4\text{x}10^4$ cm^{-3} what is the ionization production rate ?

E region is in photochemical equilibrium P=L

Loss is due to recombination

$$L = k_1 N_{NO+} N_e + k_2 N_{O2+} N_e$$

$$L = k_1 0.5 N_e N_e + k_2 0.5 N_e N_e$$

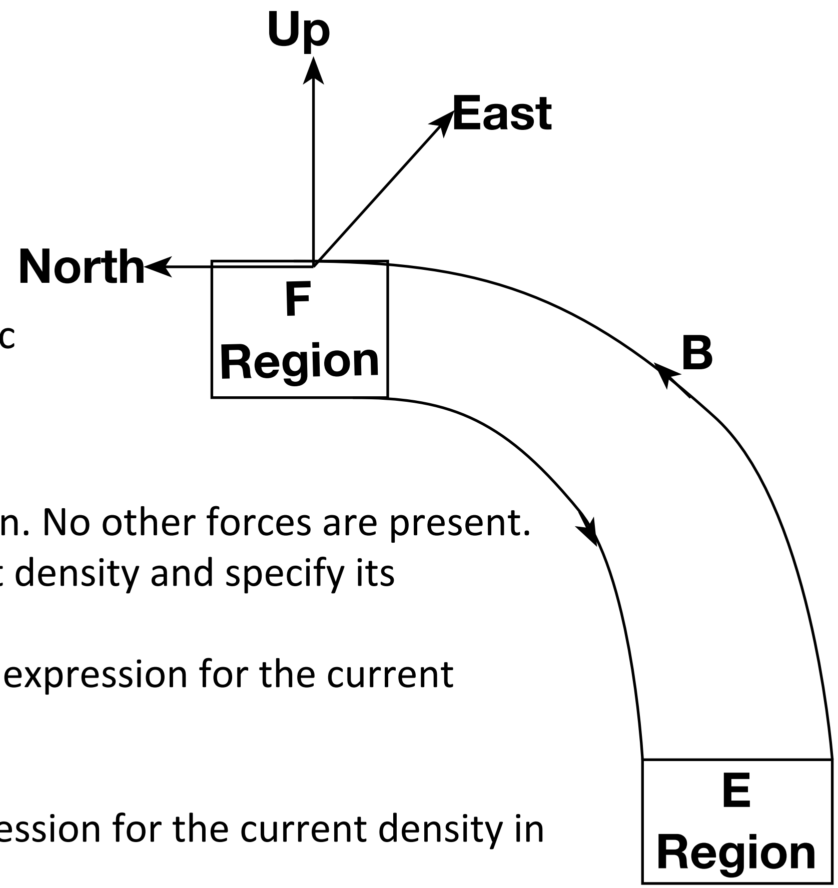
$$L = 4 \times 10^{-8} \times 0.5 N_e N_e + 1 \times 10^{-7} \times 0.5 N_e N_e$$

$$L = 7 \times 10^{-8} \times 16 \times 10^{8} = 112\ cm^{-3} s^{-1}$$

Ionosphere-Thermosphere Curents

Homework #4

Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.



A constant neutral wind blows to the east in the F region. No other forces are present.

1) Write an expression for the magnitude of the current density and specify its direction.

2) If this current is driven through the E region write an expression for the current density in terms of the electric field in the E region.

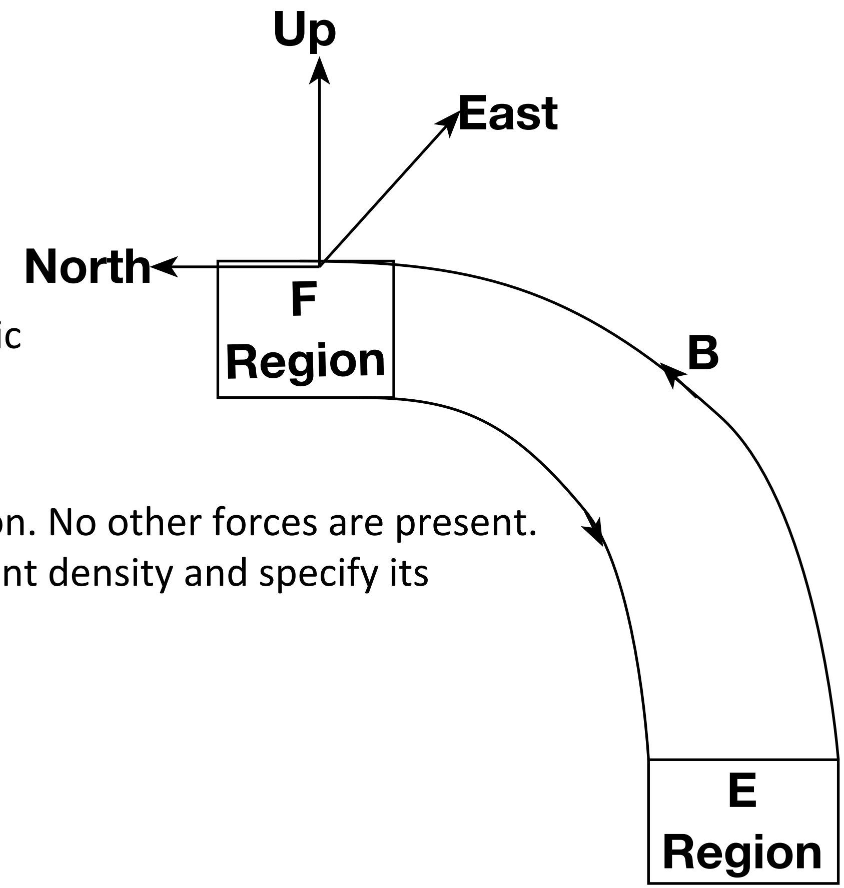
Explain your reasoning for the expression you write.

3) This electric field maps to the F region; write an expression for the current density in the F-region from this field.

4) By equating the total current density in the E and F regions write and expression for the plasma drift in the F region in terms of the neutral wind and the conductivities

5) What happens when the E-region conductance is infinite and zero respectively?

Ionosphere-Thermosphere Curents



Homework #4
Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.

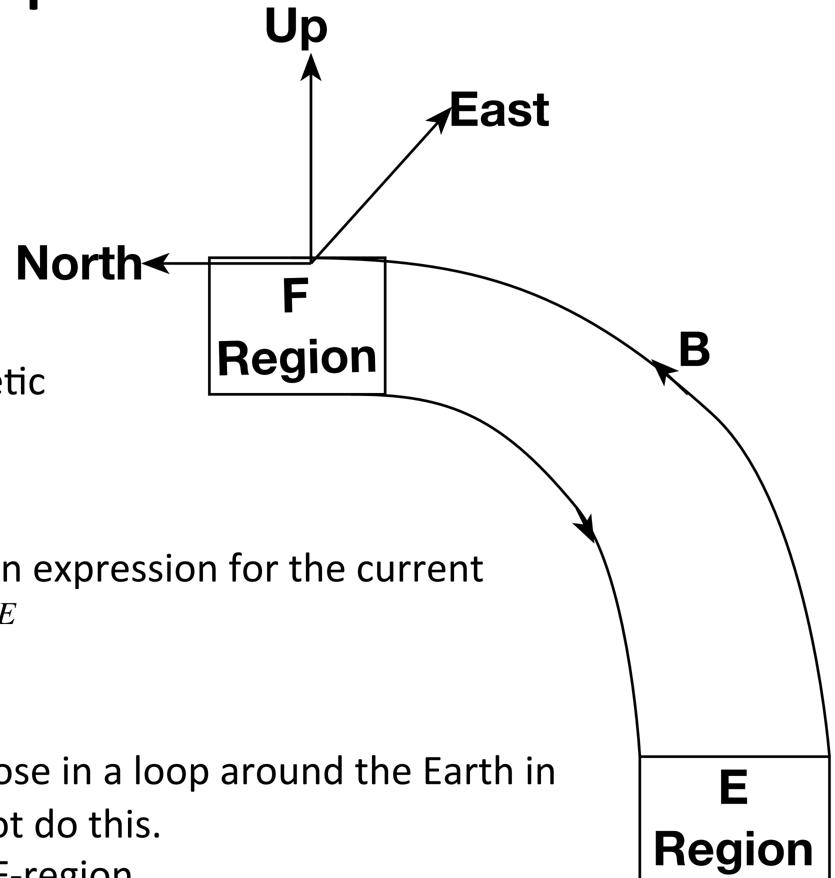
A constant neutral wind blows to the east in the F region. No other forces are present.

1) Write an expression for the magnitude of the current density and specify its direction.

$$J_F = \Sigma_F^P (U \times B)$$

Current is upward

Ionosphere-Thermosphere Curents



Homework #4
Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.

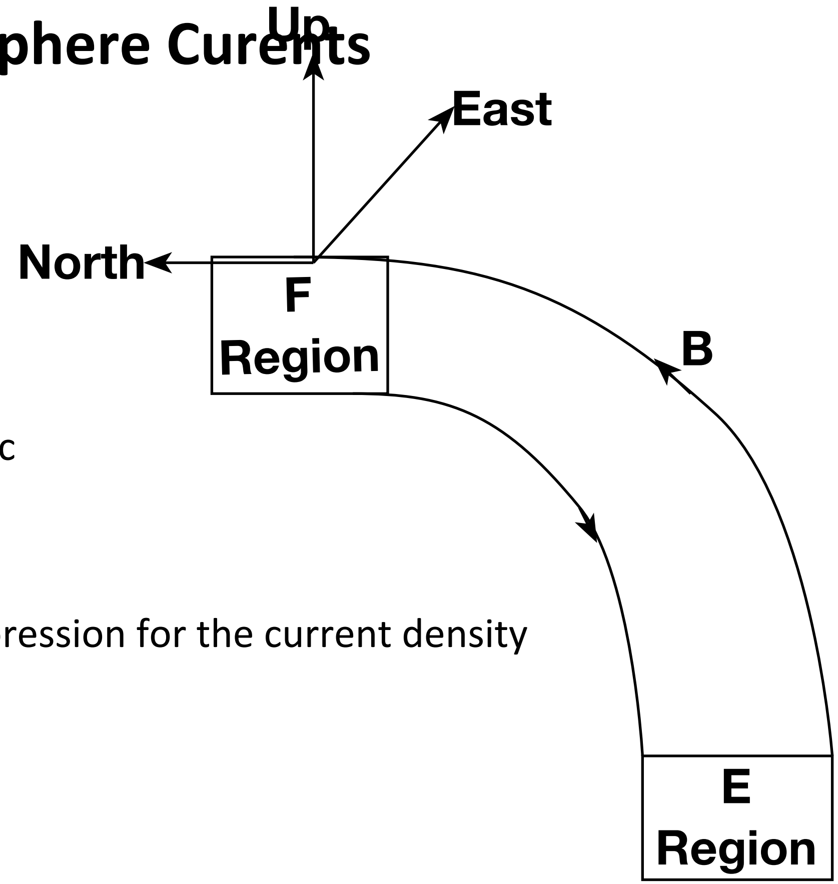
2) If this current is driven through the E region write an expression for the current density in terms of the electric field in the E region. $J = \Sigma_E E$
Explain your reasoning for the expression you write.

If the current were east-west then it would have to close in a loop around the Earth in the E region. A E-field in the east-west direction cannot do this.
There is no force to drive an east-west current in the F-region

The current must flow equatorward in the E region

$$J_E = \Sigma_E^P E$$

Ionosphere-Thermosphere Curents



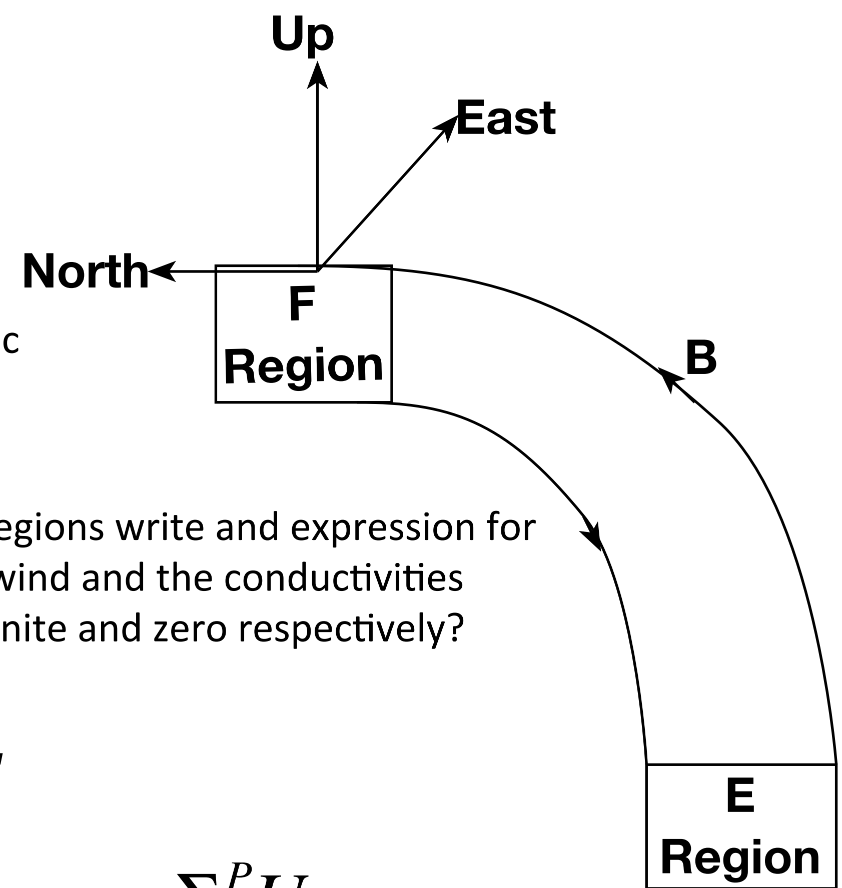
Homework #4
Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.

3) This electric field maps to the F region; write an expression for the current density in the F-region from this field.

This current is directed vertically downward

$$J_F = \Sigma_F^P (UB) - \Sigma_F^P E$$

Ionosphere-Thermosphere Curents



Homework #4
Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.

4) By equating the total current density in the E and F regions write and expression for the plasma drift in the F region in terms of the neutral wind and the conductivities
5) What happens when the E-region conductance is infinite and zero respectively?

$$J_F = \Sigma_F^P UB - \Sigma_F^P E = J_E = \Sigma_E^P E$$

$$E = \frac{\Sigma_F^P UB}{\Sigma_F^P + \Sigma_E^P} \quad ; \quad V_P = \frac{E}{B} \Rightarrow V_P = \frac{\Sigma_F^P U}{\Sigma_F^P + \Sigma_E^P}$$