21-12-2015

School of Environment & Natural Resources (SENR)
End-Semester 2015 (Monsoon Semester)
M.Sc. Ist Sem
EES 520 : Atmosphere, Weather & Climate

Max Marks : 50 **Time : 3 hours**

Section A : Mulitple choice questions : Choose one among four options, only one is correct. **(2 Marks each)**

1. In tropical region an aircraft is flying at an altitude of 10 km. At that altitude the temperature is – 40 °C. What is the ambient temperature on the ground ?
(A) 25 °C
(B) 40 °C
(C) 30 °C
(D) 20 °C

2. Assertion (A) : Upper atmosphere shields life on earth.
Reason(R) : Ultraviolet radiations are absorbed in the upper atmosphere.

Choose the correct answer :
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
(C) (A) is true and (R) is false.
(D) (A) is false and (R) is true.

3. In which layer do virtually all weather phenomena take place?
(A) Mesosphere.
(B) Stratosphere.
(C) Thermosphere.
(D) Troposphere.

4. Which of the following wind is the result of balance between pressure gradient and Coriolis force.
(A) Geostropic wind
(B) Polar Wind
(C) westerlies
(D) Trade Winds

5. Doldrum lies on the
(a) tropic of cancer
(b) equator
(c) tropic of capricorn
(d) poles

6. Cyclones are
(a) high pressure zone surrounded by low pressure zones
(b) low pressure zone surrounded by high pressure zones
(c)condition of linear decrease of pressure gradient
(d) none of the above

7. Atmospheric window lies between
   (a) 2 to 4 μm
   (b) 4 to 8 μm
   (c) 8 to 14 μm
   (d) 16 to 20 μm

8. Coriolis force is zero and maximum at
   (a) equator and pole,
   (b) pole and equator,
   (c) equator and tropic of cancer,
   (d) equator and tropic of Capricorn,
   respectively.

9. Dry adiabatic lapse rate is .... the moist adiabatic lapse rate
   (a) higher than
   (b) lower than
   (c) equal to
   (d) not comparable to

10. Most of the radiation emitted by a human body is in the form of
   (a) ultraviolet radiation and is invisible
   (b) visible radiation but is too weak to be visible
   (c) infrared radiation and is invisible
   (d) humans do not emit electromagnetic radiation

Section B : Answer the following: **(5 Marks each)**

11. Which are the fundamental forces governing the dynamics of the atmosphere? Derive an expression for the pressure gradient force.

12. What is geostrophic approximation? Explain geostrophic wind.

13. Answer any **ONE** of the following:

(i) If pressure increases by 1 kPa eastward across a distance of 500 km, then what is the geostrophic wind speed, given are the air density ρ = 1 kg/m^3, and Coriolis parameter f = 10^{-4} s^{-1}.

(ii) Explain gradient wind and cyclostrophic wind.

14. Explain tropical weather system. What are the major differences between mid-latitude weather and tropical weather?

15. Describe clouds classification on the basis of its shape and the height of occurrence.

16. Answer any **ONE** of the following :

i. The pressure (P) and temperature (T) for the first three atmospheric level in the tropics are given as follows :
P = [962.35,891.25,825.41]; hPa
T = [297.78,293.07,289.89]; K
Calculate potential temperature for first two pressure-levels. Plot a rough sketch for the potential temperature variation with pressure levels up in the atmosphere. (R = 287 J/(kg-K); C_p = 1004.67 J/(kg-K).

ii. Use the temperature, pressure data from the above problem [16(i)] . Calculate the geopotential height for first two pressure levels

$$Z_T = -H \ln\left(\frac{p}{p_0}\right);$$

where $H = \frac{R\bar{T}}{g_0}$;

$Z \equiv \frac{\phi(z)}{g_0}$, is the geopotential height, where g_0=9.8 m/s^2

Also calculate potential temperature

$$\phi = T\left(\frac{p_0}{p}\right)^{\frac{R}{c_p}}$$

for the first two levels. Plot a rough sketch for the variation of potential temperature with geopotential height.

iii. Use following recursive equation to calculate air pressure (p) as a function of altitude from

$$p_k \approx p_{k+1} - \rho_{k+1} g_{k+1}(z_k - z_{k+1})$$

Where p_k is the pressure at any upper altitude z_k, and p_{k+1}, ρ_{k+1} and g_{k+1} are pressure, density and gravity, respectively, at any lower altitude, z_{k+1}.

Assume $p_a = 1013\ hPa$ and $T = 288\ K$ at the surface, the temperature decreases at the rate of 6.5 K-km^{-1}, and the air is dry. Use it to estimate the pressure from z = 0 to 200 m in increments of 100 m. Calculate the density ρ with the equation of state at the base of each layer before each pressure calculation for the next layer. Plot a rough sketch for the variation of pressure vs altititude.

iv. Use following equation to calculate p_a as a function of altitude from the equation

$$z = \frac{T_{a,s}}{\Gamma_s}\left[1 - \left(\frac{p_a}{p_{a,s}}\right)^{\frac{\Gamma_s R_m}{g}}\right],$$

where temperature $T_{d,s}$ = 298 K and the pressure, $p_{a,s}$ = 1013 hPa at the surface and the air is dry. $\Gamma_s = 6.5\ K/km$, is the environmental lapse rate, $g = 9.8\ m/s^2$ and $R_m = 287.04\ m^2 s^{-2} K^{-1}$, for dry air. Estimate the pressure from z = 0 to 200 m in increments of 100 m. Plot a rough sketch for the variation of pressure vs. altitutde.

v. Use following equation to calculate p_a as a function of altitude:

$$p_a = p_{a.ref}\, e^{-\frac{z - z_{ref}}{H}}$$

Assume T = 298 K and $p_a = 1013\ hPa$ at the surface, the air is dry, and the temperature decreases from the surface at 6.5 K km^{-1}. Use the program to estimate the pressure from z = 0 to 200 m in increments of 100 m, calculating the scale height[1] (H) for each layer. Plot a rough sketch for the variation of pressure vs. altitutde.

[1] The scale height H is the height above a reference height at which pressure decreases to 1/e of its value at the reference height. The scale height H is given by

$$H = \frac{k_B T_v}{\bar{M} g};$$

Where,

$k_B = Boltzman\ constant = 1.380658 \times 10^{-23}\ kg - m^2 s^{-2} K^{-1} molec.^{-1}$

$T_v = virtual\ temperature$ (assume it to be equal to normal temperature T

$\bar{M} = average\ mass\ of\ one\ air\ molecule = 4.8096 \times 10^{-26}\ kg$

vi. Following are the equations for the saturation vapor pressure of water over liquid and ice :

$$p_{v,s} = 6.112 \exp\left[6816\left(\frac{1}{273.15} - \frac{1}{T}\right) + 5.1309 \ln\left(\frac{273.15}{T}\right)\right]$$

and

$$p_{v,I} = 6.112 \exp\left[4648\left(\frac{1}{273.15} - \frac{1}{T}\right) - 11.64 \ln\left(\frac{273.15}{T}\right) + 0.02265(273.15 - T\right],$$

respectively. Use these equations to estimate $p_{v,s}$ at 0°C and 50°C and $p_{v,I}$ at −50°C and 0°C. Plot a rough sketch for the variation of $p_{v,s}$ vs. temperatue (T).

vii. Calculate $p_{v,s}$, $p_{v,I}$, (from problem 16 (vi)) and T_D[2] versus altitude. Assume T is 298 K at z = 0 km and decreases 6.5 K km^{-1}. Assume also that f_r[3] = 90 percent at all altitudes. Use this to estimate parameters from z = 0 to 200 m in increments of 100 m. Plot a rough sketch for T_D vs altitude.

$g = accl.\ due\ to\ gravity = 9.8\ m/s^2$

[2] T_D is the dew point temperature given as

$$T_D = (4880.357 - 29.66 \ln p_v)/(19.48 - \ln p_v)$$

[3] f_r is the relative humidity.