The Open University of Sri Lanka
B.Sc. Degree Programme -Level 05/ 2021/2022
Final Examination 2022
PHU 5302 - Atmospheric Physics
Duration: *Two (2) hours*

Date: 18th October 2022 **Time: 9.30 a.m. to 11.30 a.m.**

R_d=287 J K^{-1} kg^{-1} g_0 = 9.81 m/s^2 P_0 = 1013.25 hPa ε =0.622

Wien's displacement constant = 2.897 ×10^{-3} meter-kelvin

Stefan-Boltzmann constant = $5.67 \times 10^{-8}\ W\ /\ m^2\ K^4$.

Density of the air 1.225 kg m^{-3}.

The angular velocity of rotation of the Earth is 7.25×10^{-5} s^{-1}.

Answer 4 questions only.

01.

(a) Compare and contrast the homosphere and heterosphere?

(4 marks)

(b) What conditions lead to the formation of Nacreous clouds?

(4 marks)

(c) The atmospheric boundary layer is distinguished from the rest of the atmosphere due to its unique characteristics.

I. Clearly define the atmospheric boundary layer?

(2 marks)

II. What is meant by "temperature inversion", and how does it intensify smog in a polluted city?

(5 marks)

(d) State the three source that generate turbulence eddies causing frictional force.

(3 marks)

(e) Wind is blowing parallel to the isobars at a location (40 ^{0}N, 80 ^{0} W) in the Northern hemisphere. The pressure drops by 4 mb (4 hPa) for each 200 km of distance north. Assuming that there is no pressure change in the longitude direction,

I. Calculate the Coriolis parameter.

3 marks)

II. Calculate the geostrophic wind components at that location.

(4 marks)

02.

(a) Briefly explain, what happens to the atmospheric pressure, when there is an increase in

I. temperature
II. volume
III. amount of gas

(6 marks)

(b)

I. Define Geopotential and Geopotential height. State all symbols used.

(2 marks)

II. Starting from the hydrostatic equation, derive the equation for the thickness of the layer between two pressure levels, P_1 and P_2: $\Delta Z = \frac{R_d}{g_0}\int_{P_2}^{P_1} T_v \frac{dP}{P}$

(6 marks)

(c) Calculate the pressure change at a fixed elevation, 3500 m, when the atmosphere warms up from -11 ^{0}C to -3 ^{0}C.

(5 marks)

(d) Explain why the air escaping from the valve of a bursting tire feels cool. Use according to the first law of thermodynamics to scientifically explain your answer. You may consider air in the tire is at constant volume in terms of specific heat capacity at constant volume (C_v).

(6 marks)

03.

(a)

I. Define mixing ratio and give an expression for it. State the symbols used.

(2 marks)

II. Show that the mixing ratio can be written as $w = \frac{e}{P-e}\,\varepsilon$.

(3 marks)

III. If air contains water vapor with a mixing ratio of 6.3 g kg^{-1} and the total pressure is 1018.3 hPa, calculate the vapor pressure.

(3 marks)

(b) Why the dew point is a convenient indicator of the level of human discomfort?

(3 marks)

(c) Briefly discuss the "absolutely stable" and "absolutely unstable" atmosphere using appropriate diagrams for both saturated and unsaturated air parcels.

(6 marks)

(d) Starting from potential temperature, show that the lapse rate for dry adiabatic atmosphere as $\frac{dT}{dz} = -\frac{g}{C_P}$.

(8 marks)

04.

(a) Explain how the earth's natural greenhouse effect works. What is the difference between natural and enhanced greenhouse effect?

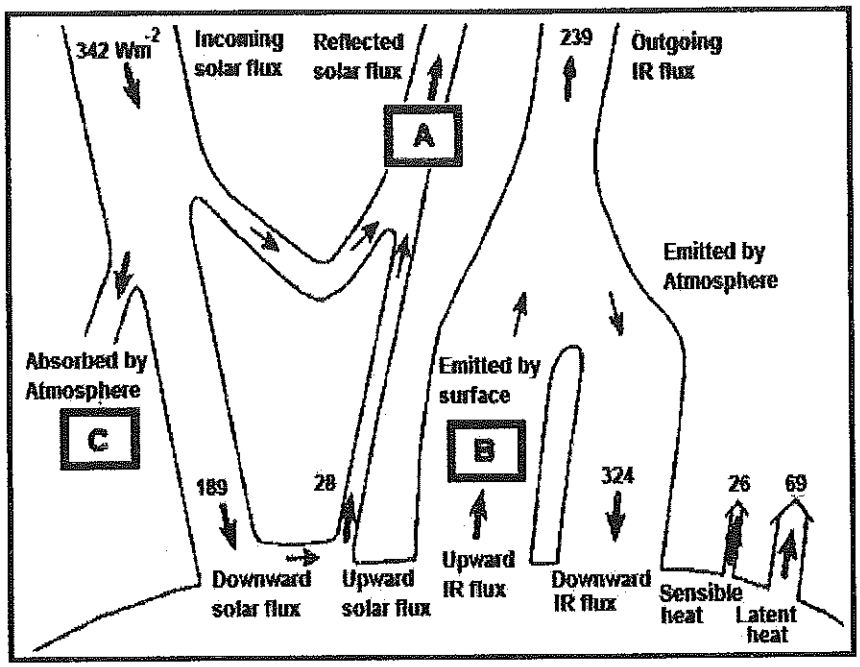
(4 marks)

(b) Considering the gains and losses of global, atmospheric and surface radiation balance of the Earth's energy budget diagram below. In the figure, all the radiation flux are in Wm^{-2}.

I. State the equations for gains and losses of global, atmospheric and surface radiation balance.

II. Determine the energy flux components A, B and C.

(9 marks)



(c) Human body temperature is about 37^0C.

I. At what wavelength does the human body emit its maximum temperature radiation?

II. What part of the electromagnetic spectrum is this in?

III. Determine the rate of radiative energy emitted from a square meter of the body surface.

(5 marks)

(d)

I. Describe how a 22° sun halo forms.

II. How is the formation of sundogs different from that of a halo?

III. Explain why, on a cloudless day, the sky will usually appear milky white before it rains and a deeper blue after it rains

(7 marks)

05.

(a) What are five factors that determine the growth of a cloud droplet in the atmosphere?

(5 marks)

(b) Briefly discuss the process involved in the formation of warm-cloud precipitation.

(5 marks)

(c) What is the role of supercooled water droplets in the formation of cold-cloud precipitation?

(5 marks)

(d)

I. Describe the development and the nature of the mature stage a thunderstorm?

(4 marks)

II. What are the main features of mesoscale convective complexes (MCCs)?

(3 marks)

(e) What is the role of thunderstorms in global electric circuit?

(3 marks)

06.

(a) What is the difference between inertial and non-inertial reference frames?

(2 marks)

(b) Explain the active remote sensing technique giving some examples.

(3 marks)

(c) Explain the difference between observation geometries, limb view, nadir view and solar occultation with an aid of a diagram.

(6 marks)

(d)

I. What is meant by climate feedback?

(2 marks)

II. Briefly describe the 2 main types of climate feedbacks in the earth's climate system.

(4 marks)

(e) Briefly explain following climate feedback mechanisms

(8 marks)

I. Albedo
II. Cloud cover

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