SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2017/2018

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN METEOROLOGY

SMR 301: DYNAMIC METEOROLOGY

DATE: 06TH DECEMBER, 2017   **TIME: 4.00 -6.00 PM**

INSTRUCTIONS TO CANDIDATES
   (a) Answer <u>ALL</u> the Questions in Section A
   (b) Answer <u>ANY THREE</u> Questions in Section B

SECTION A: Answer ALL Questions in this Section   **(30 Marks)**

Question 1
   (a) State the main constituents of the earth's atmosphere   **(2 Marks)**
   (b) State the first law of thermodynamics   **(2 Marks)**
   (c) State Newton's second law of motion for an absolute frame   **(2 Marks)**
   (d) Define the following terms
   i)   Thermal wind   **(4 Marks)**
   ii)   Scale Analysis and the steps undertaken in the process   **(4 Marks)**
   (e) Identify factors that might lead to applicability of Newton second law   **(4 Marks)**
   (f) Use any motion property to distinguish between the fundamental and virtual forces
                                                                          (2 Marks)
   (g) Why are complete momentum equations referred to as primitive equations
                                                                          (2 Marks)
   (h) Name any regions of the earth where gravitational force and centrifugal force are a) exactly the opposite, b) just tend to cancel out.   **(2 Marks)**
   (i) List the properties of Geostrophic wind   **(4 Marks)**
   (j) Explain briefly how viscous forces arise in fluid motions   **(2 Marks)**

SECTION B: Answer ANY Two Questions in this Section (**40 Marks**)

Question 2

(a) Derive the equation for the atmospheric pressure at any height (Z) above the surface assuming that air density is a constant (**5 Marks**)

(b) Write down the equation of state, and outline why it is applicable to the earth's atmosphere (**4 Marks**)

(c) Use a geometrical illustration of your choice to derive the equation for the pressure gradient force (**4 Marks**)

(d) Considering impacts of R on the centrifugal force, how will the magnitude of the centrifugal force over the poles compare with that over the equator (**3 Marks**)

Question 3

(a) Perform the scale analysis of horizontal components of the equation of motion, and using your results, describe briefly

    a) Geostrophic balance (**2 Marks**)

    b) Quasi geostrophic balance (**2 Marks**)

    c) Validity of geostrophic balance over the equator (**2 Marks**)

    d) Diagnostic and prognostic equations (**2 Marks**)

    e) The usefulness of Rossby number in dynamic meteorology (**2 Marks**)

(b) Write down geostrophic wind vector and magnitude in

    a) x, y, z, t coordinates

    b) x, y, p, t coordinates

(c) Discuss why actual large winds approximate geostrophic motions (**4 Marks**)

Question 4

(a) Write down the components of the equation of motion in spherical coordinates (**6 Marks**)

(b) By use of Cartesian coordinates, write down the components of momentum equation in the zonal, meriodional and vertical directions. (**6 Marks**)

(c) Why is it necessary to transform Newton's second law of motions to describe air motions relative to the earth (**3 Marks**)

(d) Write down the equation of motion, for an air parcel of unit mass, relative to a rotating coordinate frame in vector form and name all terms (**5 Marks**)

Question 5

(a) Define baroclinic and barotropic atmospheres and for both, state the implications of thermal wind relationship (**8 Marks**)

(b) Discuss the observational manifestations of thermal wind relationship (**4 Marks**)

(c) Describe briefly how divergence arises in atmospheric motions (**4 Marks**)

(d) Briefly describe how vorticity arises in atmospheric motions (**4 Marks**)